THE

PROCEEDINGS AND TRANSACTIONS

OF THE

Nova Scotian Institute of Science,

HALIFAX, NOVA SCOTIA.

VOLUME X.

(BEING VOLUME III OF THE SECOND SERIES.

1898-1902.

WITH FOUR PORTRAITS AND SEVEN PLATES.

HALIFAX:
PRINTED FOR THE INSTITUTE BY THE MCALPINE PUBLISHING CO., LTD.
1903.

CONTENTS.

PROCEEDINGS.

SESSION OF 1898-99 :— PAGE

Presidential Address, by Alex. McKay i
Obituary Notices of John Somers, M. D., Jules Marcou, and John Ambrose, D. C. L iii
Notes on the Early History of the Institute v
The Position of Science in our Educational System viii
Report of the Treasurer xv
Report of the Librarian xv
Dr. A. H. MacKay on the Diatomaceæ of Nova Scotia xix
Lee Russell, B. S., on School-Room Air xxi
Prof. J. G. MacGregor, and W. A Macdonald, on the Variation with tension, of the elastic properties of vulcanized india-rubber xxviii

SESSION OF 1899-1900 :—

Presidential Address, by Alex. McKay xxxv
Obituary Notices of J. J. Fox, and Sir J. W. Dawson xxxvi
The utility of a Scientific Library and of a properly conducted Museum xxxix
Report of the Treasurer xli
Report of the Librarian xlii
A. H. McKay, LL. D., on the Sub-divisions of the Carboniferous System of Canada xlvii
H. S. Poole, F. G. S., on the Periodical Appearance of Ants in a Chimney, and on an unusual site for a Humble-bees' nest xlix
A. H. MacKay, LL. D., on Material taken from the bottom of the Atlantic by the cable steamer *Minia* l

SESSION OF 1900-01 :—

Presidential Address, by Dr. A. H. MacKay liii
On the Scope of Work of the Institute liii
Provincial Museum and Science Library lvi
Deaths of Captain Trott, and Rev. A. C. Waghorne lvii
Reports of Treasurer and Librarian lviii
Officers of 1900-1901 lviii
Resolution of Regret on Death of Dr. J. R. DeWolf lxi
H. S. Poole, F. R. S. C., on the Davis Calyx Drill. (Title only) lix

PAGE

Prof. H. W. Smith, B. Sc., on Rotation of Leguminous Crops, and Preservation and Use of Tops of Turnips and other Root Crops. (Title only) lx
A. H. MacKay, LL. D., on Gravel taken from the bottom of the Atlantic, forty miles west of Sable Island (Title only) lxi
Prof. J. G. MacGregor, D. Sc., on the Use of the Wheatstone Bridge with Alternating Currents. (Title only) lxii
W. H. Magee, Ph. D. on the Rare Earths: their Scientific Importance as regards the Periodic Law lxii
W. L. Bishop, exhibition of collection of Nova Scotian Birds' Eggs. lxxviii
Resolution relative to the formation of Branches of the Institute lxxviii
E. Gilpin, LL. D., &c., on Further Exploration in the Torbrook Iron District. (Title only) lxxix
Sketch of the Life of John Matthew Jones. By H. P. *(With portrait)* lxxx

SESSION OF 1901-1902:—

R. W. McLachlan, Talk on Roman Coins. (Title only) lxxxiii
A. H. Cooper Prichard, Exhibition and Remarks on Roman Coins of the Provincial Museum. (Title only) lxxxiii
Presidential Address, by Dr. A. H. MacKay lxxxiv
Obituaries of Dr. J. R DeWolfe, Capt. W. H. Smith, and Rev. Moses Harvey lxxxiv
Work of the Institute lxxxvi
Provincial Museum and Science Library. .... lxxxvii, lxxxviii
Provincial Progress lxxxviii
Malaria, Yellow Fever and Sheep-fluke Object Lessons . xci, xcii, xcv
Marine Biological Station xcvi
Treasurer's and Librarian's Reports .... xcvii, xcviii
Report on Kings County Branch of the Institute xcviii
Officers for 1901-1902 xcviii
Dr. A. H. MacKay, on a condensed form of *Botrychium ternatum* found at Blomidon, N. S. xcix
Miss A. Louise Jaggar, Notes on the Flora of Digby County, N. S. (Title only) c
R. S. Boehner, B. Sc., On the Standardization of Hydrochloric Acid with Borax. (Title only) ci
Harry Piers. Sketch of the Life of Andrew Downs, founder of the first zoological garden in America. *(With portrait)* cii
Prof. E. Haycock. The Kings County Branch of the N. S. Institute of Science: Outline of purposes and aims of the Society... cix

TRANSACTIONS.

SESSION OF 1898-99:— PAGE

1. Statistics of Expenditure and Consumption in Canada,—by Prof. J. Davidson, M. A., Phil. D., University of New Brunswick, Fredericton 1

II. On a Test, by the Freezing-Point Method, of the Ionization Co-efficients determined by the conductivity method, for Solutions containing Potassinm and Sodium Sulphates,—by E. H. Archibald, M. Sc., 1851 Exhibition Science Scholar, Dalhousie College, Halifax, N. S 33

III. On the Conductivity, Specific Gravity, and Surface Tension of Aqueous Solutions containing Potassium Chloride and Sulphate, —by James Barnes, B. A., Dalhousie College, Halifax, N. S.. 49

IV. On Finding the Ionization of Complex Solutions of given concentration, and the converse problem,—by Prof. J. G. MacGregor, Dalhousie College, Halifax, N. S 67

V. New Mineral Discoveries in Nova Scotia,—by E. Gilpin, Jr, A.M., LL.D., F.R.S.C., Inspector of Mines, Halifax, N. S.... 79

VI. Phenological Observations, Canada, 1898,—by A.H MacKay, LL.D., Halifax 91

VII. On a Fish *(Chylomycterus schœpfi)* new to Nova Scotia,—by Harry Piers 110

SESSION OF 1899-1900:—

I. On the Relation of the Viscosity of Mixtures of Solutions of certain Salts to their state of Ionization,—by James Barnes, B. A., Dalhousie College, Halifax, N S.. 113

II. On the Calculation of the Conductivity of Aqueous Solutions containing Hydrochloric and Sulphuric Acids,—by the same.... 129

III. On the Depression of the Freezing-Point by mixtures of Electrolytes,—by the same 139

IV. On the Sub-divisions of the Carboniferous System in Eastern Canada, with special reference to the position of the Union and Riversdale Formations of Nova Scotia, referred to the Devonian System by some Canadian Geologists,—by H. M. Ami, M.A, D.Sc., F.G.S., of the Geologcal Survey of Canada, Ottawa 162

V. The Natural History of Money,—by Prof. J. Davidson, Phil. D., University of New Brunswick, Fredericton, N. B 179

VI. On the presence of Acid Sulphate of Copper in mixtures of Aqueous Solutions of Sulphuric Acid and Copper Sulphate,—by Charles F. Lindsay, Dalhousie College, Halifax, N. S...... 205

PAGE

VII. On a Diagram of Freezing-Point Depressions for Electrolytes,—by Prof. J. G. MacGregor, D. Sc., F. R. S., Dalhousie College, Halifax, N. S. 211

VIII. Geological Nomenclature in Nova Scotia, by Hugh Fletcher, B A., of the Geological Survey of Canada 235

IX. Notes on a Cape Breton mineral containing Tungstein, and on the effect of washing certain Cape Breton coals,—by Henry S. Poole, F. G. S., F. R. S. C., Assoc. Roy. Sch. Mines, etc., Stellarton, N. S 245

X. Minerals for the Paris Exhibition,—by E Gilpin, Jr., LL. D., F. R. S. C., Inspector of Mines 248

XI. On the Variation of the Rigidity of Vulcanized India-Rubber with Tension,—by Thomas C. Hebb, B. A., Dalhousie College, Halifax, N. S 273

XII. Records of Post-Triassic Changes in Kings County, N. S.,—by Prof. E. Haycock, Acadia College, Wolfville, N. S 287

XIII. Phenological Observations, Canada, 1899,—by A. H. MacKay, LL. D., Halifax, N. S 303

XIV. A Fresh-water Sponge [*Heteromeyenia macouni*, n. sp.] from Sable Island,—by the same 319

SESSION OF 1900-01:—

I. Geological Nomenclature of Nova Scotia: New Glasgow Conglomerate, by Hugh Fletcher, B. A., Geological Survey of Canada, Ottawa 323

II. Description of Tracks from the fine-grained Siliceouous Mudstones of the Knoydart Formation (EoDevonian) of Antigonish County, N. S.,—by H. M. Ami, D. Sc., F. G. S., Geological Survey of Canada, Ottawa. *(With plate.)* 330

III. On Drift Ice as an Eroding and Transporting Agent,—by Walter H. Prest, M. E., Bedford, N S 333

IV. On a Polished Section of Stigmaria, showing an axial cellular structure,—by Henry S. Poole, F. R. S. C., Halifax. *(With two plates.)* 345

V. The Star-nosed Mole *(Condylura cristata)*, its breeding habits, &c.,—by Watson L. Bishop 348

VI. Recent Developments with the Calyx Drill in the Nictaux Iron Field,—by D'Arcy Weatherbe, C. E., Mines Department of N. S., Halifax. *(With two plates.)* 350

VII. The Geological History of the Gaspereau Valley, N. S.,—by Prof. Ernest Haycock, Acadia College, Wolfville, N. S *(With plate.)* 361

VIII. Fossils, possibly Triassic, in Glaciated Fragments in the Boulder-clay of Kings County, N. S.,—by Prof. Ernest Haycock 375

PAGE

IX. (1) Phenological Observations of the Botanical Club of Canada, 1900. (2) Abstract of Phenological Observations on Flowering of ten Plants in Nova Scotia, 1900, with (3) Remarks on their Phenochrons,—by A. H. MacKay, LL. D., &c., Halifax 379

X. Rainfall Notes, Nova Scotia,—by F. W. W. Doane, City Engineer, Halifax 399

SESSION OF 1901-1902:—

I. On a Determination of the Freezing-point Depression Constant for Electrolytes,—by T. C. Hebb, M. A., Dalhousie College, Halifax 409

II. On the Determination of Freezing-point Depressions of Dilute Solutions of Electrolytes,—by T. C. Hebb, M. A., Dalhousie College, Halifax 422

III. The Progress of Geological Investigation in Nova Scotia,—by R. W. Ells, LL. D., F. R. S. C., of the Geological Survey of Canada, Ottawa 433

IV. On the Upper Cambrian Age of the Dictyonema Slates of Angus Brook, New Canaan, and Kentville, N. S.,—by H. M. Ami, D. Sc., F. G. S., F. R. S. C., of the Geological Survey of Canada, Ottawa 447

V. Notes on on Dr. Ami's paper on the Dictyonema Slates of Angus Brook, New Canaan, and Kentville, N. S.,—by Henry S. Poole, Assoc. Roy. Sch. Mines, F. G. S., F. R. S. C., Halifax. 451

VI. Supplementary Notes on Drift Ice as a Eroding and Transporting Agent,—by Walter H. Prest, M. E., Bedford. 455

VII. Agricultural Credit,—by Prof. John Davidson, Phil. D., Univ. of New Brunswick, Fredericton 458

VIII. Phenological Observations in Nova Scotia and Canada, 1901,—by A. H. MacKay, LL. D., F. R. S. C., Supt. of Education, Halifax 486

IX. Labrador Plants (collected by W. H Prest on the Labrador coast, north of Hamilton Inlet, from 25th June to 12th Aug, 1901),—by A. H. MacKay, LL. D., etc., Halifax 507

APPENDICES:—

I. List of Members, 1898-1899 I

II. List of Members, 1899-1900 V

III. List of Members, 1900-1901 VIII

IV. List of Members, 1901-1902 XIII

INDEX TO VOLUME X. XVII

WESLEY

John Somers

PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1898-99.

Annual Business Meeting.

Legislative Council Chamber, Halifax, 14th March, 1898.

The President, Mr. A. McKay, in the chair.

The President addressed the Institute, as follows:—

Gentlemen,—It is an educational axiom of the first importance that in presenting a new subject for study it should in some vital way be correlated with ideas already in the mind of the student.

Guided by this principle, I should at the beginning of another year's work of this Institute, review briefly the progress made during the past year. This was in many respects most unsatisfactory. Never before did we have so much difficulty in securing papers for our ordinary meetings. We had in all thirteen communications, of which eleven were papers, three read by title. Six of these papers gave the results of investigations, conducted chiefly by two Dalhousie students in a physico-chemical field, regarding the behavior of ions under certain conditions. There were two papers relating to Geology, one to Natural History, one to Ethnology, one to Botany. In addition, Mr. Twining exhibited a model of a Pivot-boat, and explained its working, and Dr. MacGregor gave an address on Laboratory Methods.

It may, however, be found that the sum total of scientific knowledge has been increased somewhat by those original researches which were conducted in Dalhousie College, and that the printed results may be utilized by other investigators. Dr. Bailey's very interesting papers on

the structure and geologic formation of Digby Basin throw much light on some hitherto obscure problems of the geology of that region.

The teaching of science in our public schools would be greatly improved if the methods recommended by Dr. MacGregor, in his able address on Physical Laboratory Work, were generally adopted.

It is too soon yet to attempt any prediction regarding Mr. Twining's novel experiments in boat-sailing. They seem calculated to lead to a great improvement in the quality of speed by showing how friction and water displacement may be reduced to a minimum.

Dr. MacKay's phenological observations, assisted as he is by a large corps of observers all over the Dominion, may lead to some important generalizations regarding the relation of organized life to latitude and other climatic conditions.

I have referred to the difficulty of securing papers on scientific subjects for our ordinary meetings. This does not necessarily imply that our members are becoming less interested in science than formerly. It may and probably does mean that work in science like work in every other department of human life is becoming more specialized. Our earlier scientists worked in comparatively new fields. It was then an easy matter to find plants or animals not previously known in our country and with the aid of good text books to describe and identify them. The first explorers in a rich gold mine find it easy to make fortunes. Those who come later require much greater skill and patience. It did not require much scientific knowledge forty years ago to enable a man to acquire some reputation in the field of science. The possibilities in this respect made it more attractive as an outlet for the expenditure of those surplus energies which are nowadays required for the severer business competition of a more congested state of society.

Then, a little enthusiasm, a vasculum, an insect net and a pocket-glass comprised all the outfit necessary to enable a man to write valuable papers and to give him a good standing in our Institute. Now he requires a thorough scientific training, costly scientific apparatus, and years of patient toil to be able to add a single new or valuable idea to our scientific knowledge. It is not, therefore, difficult to understand that scientific pursuits as a recreation are every year becoming less attractive and are being left to those who make of them the business of life.

While, in some departments of natural science, such as natural history, elementary electricity, and geology, the charm of novelty, ease

of acquisition, and admiration for showy experiments no longer attract our older members, they should not lose their potency with the students of our high schools and academies.

The older members should, however, have some compensation in those departments of science, a practical knowledge of which is every day opening up mines of national wealth ; for our love of money is supposed to grow with our advancing years and we should be willing to make great sacrifices for what tends so greatly to enrich our country.

During the past year we admitted two new members ; but on the other hand, we lost by death three of our most prominent men, concerning whom you will permit me to say a few words.

JOHN SOMERS, M. D., died on the 13th of March. He was born in Newfoundland, came to Halifax in early infancy and received a fairly good education.

In conducting a drug store he acquired a taste for the study of medicine. One year before the close of the American civil war he was graduated from Bellevue in time to spend a year in active service as an army surgeon. He then returned to Halifax where he remained in the practice of his profession until his death.

He took an active part in the establishment of the Halifax Medical College in which he lectured for many years as Professor of Physiology and Examiner in Medicine. He was an active and useful member of society. In 1879 and 1880 he was a member of the Halifax School Board. He also served for some time as Chairman of the Public Charities Board.

In January, 1875, he was elected member of this Institute, and one year after, he read his first paper on his favorite subject, Botany. Of his 18 published papers, 14 related to Botany, 3 to Zoology, and 1 to the use of the Microscope. He had three papers in course of preparation when he died. He was an authority on the Mosses and Fungi of Nova Scotia and an accomplished microscopist. From a busy professional life he managed to snatch enough time to become fairly proficient in many departments of science. He was an omnivorous reader, had a good memory and well-trained powers of observation, so that whatever subject might be under discussion at our meetings he was always able to add something of value and interest. He was always ready to assist those engaged in scientific study. I first met him at one

of our Field Meetings at Grand Lake 24 years ago. I shall never forget the delightful day which I spent with him in botanizing.

JULES MARCOU, who had been one of our corresponding members since 1891, died at Cambridge on the 17th of April. He was born at Salins, France, in 1824. He studied at the College of St. Louis, Paris, but failing health led him to make an excursion to Switzerland, where he soon acquired an intense love for the study of Geology. At the age of 21 he assisted Jules Thurman in his work on the Geology of the Jura Monntains. Here he met Louis Agassiz, with whom two years later he explored the Eastern United States and Canada. In 1850 he embodied these reserches in a geological map of the United States and the British Provinces of North America. For five years he was Professor of Geology at Zurich. In 1861 we find him associated with Louis Agassiz founding the Museum of Zoology at Cambridge, U. S. A. In 1867 he was decorated with the Cross of the Legion of Honor. He was a member of many scientific societies and published many valuable papers, maps and books. In common with our own Dr. Honeyman, he took special interest in the study of the Huronian, Cambrian, and Primordial Silurian rocks, and assisted the Doctor in the identification of some of the more obscure Nova Scotian fossils of these systems. He was a strong advocate of the Taconic system, since pronounced by Dana to be identical with the Lower Silurian system. It was, upon the proposal of Dr. Honeyman who labored in the same field, that he became one of our corresponding members.

REV. JOHN AMBROSE, D. C. L., who died at Sackville, on September 12th, may be regarded as one of the founders of this Institute. Before it was organized he promised his hearty support—a promise which we shall see was faithfully kept. He was indeed proposed as a member of the first Council, but probably owing to the fact that he resided at that time at Margaret's Bay he was unable to act.

He was born in St. John of Irish parents, received his common school education at Truro, and was graduated from King's College, Windsor—receiving the degree of B. A. in 1852, M. A. in 1856, and D. C. L. in 1888.

For over 44 years he labored successfully and acceptably as a clergyman; $2\frac{1}{2}$ years at Liverpool, 3 years at New Dublin, 13 years at Margaret's Bay, 23 years at Digby and 3 years at Herring Cove, and for $2\frac{1}{2}$ years more he enjoyed at his country farm at Sackville the respite from labor which he needed and which he had so well earned.

In addition to the performance of extensive parish duties as a clergyman, he took a prominent part in other church work. He edited a religious monthly called *Church Work*, and also the *Halifax Church Chronicle.* He was a Governor of King's College—strongly opposing its union with Dalhousie. In Digby he led a successful crusade against the iniquitous system of " Farming out the Poor." He lectured in England for the Society for the Propagation of the Gospel and the Society for the Promotion of Christian Knowledge.

Amidst all these labors he found time to make science a recreation. In January, 1864, he communicated his first paper to the Institute. It was followed by a series of papers, all relating to the birds and fishes of St. Margaret's Bay—a spot which should be as well known to our Zoologists as Arisaig is to our Geologists. His paper on the Stormy Pĕtrel was republished more than once.

In October, 1863, he was elected Associate Member,—retaining that position until 1881. Again in 1890 he was elected Corresponding Member.

Dr. Ambrose was a remarkably fine specimen of a man,—physically, mentally and morally—a man to whom the leaders in any public movement for the public good could appeal with the certainty of receiving sympathy and support.

While glancing over the records I made a few notes concerning matters which struck my attention in our early history and which may interest some of you.

On the last day of the year 1862 the late J. Matthew Jones presided at a meeting held in the hall of the Halifax Medical College There were present, T. Belt, S. Gray, Dr. Gilpin, Wm. Gossip, R. G. Haliburton, Capt. Lyttleton, H. Poole, Capt. Hardy, J. R. Willis and P. C. Hill. Of this company, so far as I know, all but one have passed away.

The object of the meeting was to organize an Institute of Natural Science for Nova Scotia. This Institute grew out of another organization which had done pioneer work in science. It may be said to have been a development from the Halifax Mechanics' Institute, which, under the inspiration of men like the late Andrew MacKinlay, did very much to awaken the general public to an interest in the discoveries of of science, which at that time were coming on like a November meteoric shower.

At the first meeting the officers of the older organization resigned, and the officers of the Institute of Natural Science were elected—Mr. P. C. Hill being President. At this meeting a Constitution and Bye-Laws were adopted. Among the resolutions which passed was the following: *Resolved*, That at the next monthly meeting each member be entitled to bring a friend.

Now every member is not only entitled to bring a friend to the meetings but he is urged to do so, and to bring not one friend only but as many friends as he pleases, provided he can sufficiently interest them in the work of the Institute.

At the meeting in February, the Right Honorable the Earl of Mulgrave, Patron of the Institute was present, and after listening to the papers and discussions he expressed himself much pleased, and promised to do what he could to advance the work.

In the early meetings of our Institute so great was the general interest in scientific work that there seemed to be always a sufficient supply of scientific papers ready to be read when required. Every meeting was closed by an announcement of the titles of the papers to be read at the next. This timely announcement of the subject gave members an abundance of time to prepare to take an intelligent part in the discussions which followed every paper.

But in these busy days in which our lot has fallen we are thankful if we can announce the programme a few days in advance, and sometimes papers are read by title because they are not ready. Could not the Secretaries and President by taking thought beforehand bring about the happy state of things in this respect, that formerly existed? It is worth the attempt.

In March, 1864, we find the first announcement of the receipt of Reports of sister societies. The small beginning of our present large and valuable library consisted of three volumes, namely, the second Report of the Scientific Survey of the State of Maine, the Report of the Natural History Society of Newcastle-upon-Tyne, and the first number of our own Transactions.

Now that our library has grown to such dimensions, we should prepare a catalogue complete to date. Copies of it should be sent to our academies and to all other institutions of learning in the Maritime Provinces and to all persons whom we might wish to persuade to become members. To young students having time and inclination for

nature studies, such a catalogue would be suggestive and helpful in selecting those fields of work which have been most neglected in Nova Scotia. In the appendix to this catalogue there might be a list of the scientific books belonging to the City Public Library and to Dalhousie College, and also a yearly supplement of publications received by the Institute.

The year 1864 is also marked by the decision to have a series of Field Meetings in the summer season. The first excursion was to St. Margaret's Bay in June to investigate some Indian remains in that vicinity. These meetings were continued in 1865. They were very interesting and profitable. After visiting a locality and studying its natural history the members would assemble at some point for dinner, discussion, and the reading of papers relating to the day's work.

At a conversazione in the Horticultural Gardens on the 6th of July, there were about 200 persons present. The President delivered an address on the advantages which the Institute, if properly supported and encouraged, might be expected to confer upon the country. He afterwards gave a very interesting description of the butterflies and moths of Nova Scotia. Dr. Gilpin described the manner of taking and smoking Digby Herring. Mr. Gossip read a paper on the geological formation of Halifax. Dr. Lawson discoursed on Botany, while all the company enjoyed a repast of cakes, strawberries and cream, lemonade and ices. Thus, in the early days of this Society was the love of science fostered. The resumption of some of these old practices, which have unfortunately fallen into abeyance, would not be a retrograde movement. If we would study Nature honestly and effectively we must meet her face to face. She does not woo by proxy, by text-books, illustrations or recitations. With this principle in view then let me draw up an imaginary programme for next summer's Field Meetings.

Accompanied by friends we meet in the Public Gardens at 8.30 a. m. on the third Saturday in June, every one provided with substantial lunches. After an hour spent with Superintendent Power and Drs. MacKay and Lindsay investigating ferns and learning the scientific names of the trees and shrubs we take the street car to Point Pleasant. Here we examine the beautiful synclinal on the shore, and collect specimens of littoral fauna and flora. We then cross the Ferry to Purcell's Cove and have lunch, followed by short addresses relating to the scientific peculiarities of our immediate environment. After some

botanizing we return visiting the gas works which we inspect carefully with a view to a better comprehension of a lecture by Prof. E. MacKay, giving a scientific account of the manufacture of gas from coal, dealing particularly with the by-products, showing their chemical relations and uses.

On the third Saturday in July we would make a similar expedition to Waverly Gold Mines—crossing to Dartmouth in the steamer "Chebucto," and to our destination by train. At Waverly we would examine the gold mine and the rich lacustrine flora.

In August, for one fare we purchase a return ticket to Campbellton, N. B., to spend two days with some of the most enthusiastic scientists of the Maritime Provinces—those Professors, Principals, and other teachers who are willing to devote two weeks of their holiday season to mutual instruction and enjoyment in the forest, field and laboratory. I refer to the Summer School of Science, which will then hold its 13th annual session. The President, Mr. Geo. U. Hay, has invited the Natural History Society of New Brunswick and also this Institute to co-operate with the Summer School in a grand gathering of the representative scientific men of the Maritime Provinces. The place of meeting would be a delight to the lover of romantic scenery, while affording to the botanist and geologist exceptional facilities for field work. The occasion might be utilized for the discussion of some of the larger questions regarding scientific education that are pressing upon us. Joint resolutions from our three scientific societies would have great weight with our governments, and might lead to the extension of our technical science schools, now so miserably inadequate, or to important modification in the methods adopted to further education in general science.

Before closing, it might be expected that as a member of a Scientific Institute and teacher, I should say a few words as to the place which science occupies in our educational system, as to the place it should occupy, and also concerning the best means to be used to secure for it that place.

As to the place which it does occupy. It is found in the prescribed course of study in the form of lessons on Nature for the eight grades of the common school course, with the addition of a few specialized lessons on the simplest principles of Physics and Chemistry for Grades VII. and VIII.

In this work the teacher and pupils are required to study things and not books, to perform experiments in order to learn how substances act under varying conditions and to draw their own conclusions. Is this done? It may be fairly well done in five per cent. of the schools, with very varying degrees of success in 60 per cent., and scarcely attempted in the remainder.

The majority of teachers would do better work if they could, but they have never seen it done; they cannot learn how from books; and they have not the pecuniary or moral support that comes from a general intellectual appreciation of the material, intellectual and moral benefits resulting from scientific training.

In the curriculum for our Academies and High Schools it is taken for granted that Botany and Physics are studied for about 90 minutes a week throughout the year. Chemistry and Mineralogy about the same time in the second year, and Physiology and more advanced Physics each about two hours a week for the third year. There are very few schools, however, in which so much time is devoted to Science. The Provincial Examinations show that experimental work is almost wholly neglected. The mental confusion and crudity of conception apparent in a large proportion of the answers received would tend to show that much of the science teaching is simply a mechanical memorizing of the text-book.

In the fourth year of the High School, science is optional. In the year 1897, 23 candidates received Grade "A Classical" and only three took Grade "A Scientific." Candidates who are trained in schools where the facilities for the teaching of science are poor and where the teachers are themselves not interested in science, are not likely to select the science subjects for their Grade "A" examination. Of the 37 Academic teachers reported as holding Grade "A" there are but two of them who hold the "A Scientific" and this, notwithstanding the fact that the enthusiasm of the Superintendent of Education for scientific subjects might be supposed to influence the teachers and students in the ranks below him.

The large proportion of "Classical A's" may also be partly accounted for by the fact that a considerable number of candidates are college students, and classics still dominates the Nova Scotia colleges. For matriculation leading to the degree of B. A. the student is supposed to have studied Latin for three years, but nothing is required in Natural Science.

More or less successful attempts are being made in some of the colleges to teach science. But divided and scattered as they are—five degree conferring institutions in a small province of scarcely half a million inhabitants, with no preparatory schools capable of giving a proper preliminary science training, it is small wonder that they take little interest in the teaching of new subjects which require expensive apparatus and hard work.

I should have said that there is one preparatory school, Pictou Academy, which still retains the preëminence in science-teaching which it reached when Dr. McKay, as Principal, filled its halls with students drawn from all parts of the province.

From what I have said it will be evident that taking the schools as a whole there is but little of science-teaching, and that little is poorly done.

2. What place should science occupy in the schools?

Our Nova Scotia educationists say that it is entitled to twelve per cent. of the time devoted to the compulsory subjects, or on an average, to ten per cent. of the whole time. In Germany the gymnasia (or classical schools) through all the grades devote seven per cent. of their time to science, and a considerable amount of time besides to physical geography. In the real-gymnasium and real-schulen, science is the leading subject. We all have some idea of what the German colleges and universities are doing for theoretical science.

As might be expected in these circumstances technical education has received an enormous development. In the small kingdom of Saxony, considerably less than one-third the size of Nova Scotia, there are 111 technical institutes. Prussia has 200 such schools and 12,000 pupils. Hesse with a population of 1,000,000 has 83 schools of design, 43 for manufacturing industries and many others for artisans of various trades. How many such schools has Nova Scotia?

It might here be asked: which was cause and which, effect,—the science-teaching of the gymnasia or the technical schools? The fact that so long ago as 1837 there was nearly as much science prescribed for the gymnasia as at present, would suggest an answer.

England, slow in adopting reforms, has at last been awakened to a sense of the danger in which she stands of losing her industrial supremacy unless she gives heed to the wise teachings of her great prophet, Herbert Spencer, who years ago said: "Paraphrasing an eastern fable,

we may say that in the family of knowledges, science is the household drudge, who in obscurity hides unrecognized perfections. To her has been committed all the work; by her skill, intelligence and devotion, have all conveniences and gratifications been obtained; and while ceaselessly ministering to the rest, she has been kept in the background, that her haughty sisters may flaunt their fripperies in the eyes of the world. The parallel holds yet further. For we are fast coming to the dénouement, when the position will be changed, and while these haughty sisters sink into merited neglect, science, proclaimed as highest alike in worth and beauty will reign supreme."

The Duke of Devonshire has introduced a bill into the House of Lords which is practically a bill for the establishment of science schools. In Scotland, Sir Henry Craik's latest educational circular aims at the encouragement of Science and Art in combination with a sound scheme of general education. The course of instruction extends over three years as follows:

1. Experimental Science.—Not less than four hours a week, of which two hours must be experimental. In the third year at least three hours of practical work will be required.
2. Drawing.—At least two hours a week.
3. Mathematics, including Geometry, Mensuration, Arithmetic and Algebra.—At least four hours a week.
4. History and English Literature.—About five hours a week.
5. Geography.—About two hours a week.
6. Manual Training.—At least three hours a week.
7. One Modern Language.
8. Various other subjects of Practical Interest such as Bookkeeping, Phonography, &c.

It will be seen at once that the course very much resembles our imperative course, except in that it gives one-sixth of the time to science while we give only one-eight.

Coming to America we find that the recommendations of the Committee of Ten, of the Committee of Fifteen and of the Committee on Science Teaching in Schools to the American Society of Naturalists, all agree in recommending a course of study substantially like ours,—like our ideal course, but not like the actual course.

A consideration of these facts leads us at once to conclude that our prescribed course of study fairly well represents the best ideals of the

most advanced educationists. That it is frequently criticised arises from the fact that there are in any community very few persons possessed of sufficient knowledge of the science and history of education and at the same time of the requirements of modern civilization to enable them to judge intelligently, and further, from the fact that but few of our teachers are possessed of the necessary professional qualifications to adapt themselves and their work to the various conditions and circumstances.

To quote from Dr. Rice: "That the mass of our teachers are incompetent for any very high quality of science-teaching is a truth as unquestionable as melancholy." But it is not the fault of the teachers that they are not prepared for their work. Out of 2,485 teachers we have 1,750 who receive less than $200 a year, out of which they have to pay for board and clothing, buy educational books and magazines, and purchase the apparatus and materials for science experiments in their schools. With such miserably inadequate salaries, insecure tenure of office, and no pensions, it is no wonder that the brightest young men and women look upon teaching as but a stepping stone to other positions that offer more substantial rewards with the promise of greater permanency.

All complaints against our course of study will cease when the complainants are capable of appreciating the worth of good teaching and are willing to give the moral and pecuniary support that will call forth the best talent and training. As the country advances in population, wealth and civilization the course of study will need to be modified, but to foreshadow the coming changes at present would be unwise.

3. What means must be used to secure for science the place which it should have in the actual work of the schools and colleges?

(*a.*) Make it an imperative subject in the College Matriculation Examination for B. A.

The colleges, more than any other agency, determine the character of the education given in the schools below them. They train those who become teachers of teachers. Legislators look to them for direction in educational matters. The High Schools and Academies work slavishly to produce the kind of students upon whom they are most likely to set their seal of highest approval. They have in every learned body throughout the land an ever increasing constituency moulded by their teaching and adopting their ideals. If there is a general lack of interest in science, or if it is badly taught, the colleges are largely

responsible. If they would abandon the fetich of "culture-worship" and study the conditions of modern society they would add greatly to the inestimable benefits which they now confer upon the community.

Until the colleges take this step in advance, science will not be well taught in the schools, the colleges will not have students capable of doing the best science work; for if they neglect science until they reach their college course and give "so many years of exclusive attention to other subjects, their powers of observation and of imagination of physical phenomena are well-nigh atrophied; and the loving interest in nature, innate in every normal child, instead of being systematically developed is well-nigh extinguished."

The college can determine not only the subjects to which the academies shall in reality devote their attention; but, by the nature of their examinations, they can determine the character of the teaching. If the matriculation examination calls for experimental work it will be supplied. If the colleges neglect to exercise their power in this respect wisely they will lose it. Rival institutions unduly emphasizing the neglected work will divide with them their present constituencies. This is the experience of Germany, England, and the United States.

The growing wealth of the country and the keenness of competition in the learned professions are indications that the time has come when the colleges can safely require science for the entrance examination. Harvard has made it optional and the London University has made it imperative.

(*b*) The present Grade "A" work in the Academies should be discontinued and its place should be taken by a more thorough practical Science course for Grade "B". The "A" work cannot be properly done in the academies. It is essentially college work and should be kept where it belongs. Merely to state that Gage's Principles of Physics, Storer and Lindsay's Elementary Chemistry, Bessey's Essentials of Botany, Dawson's Hand-Book of Zoology, Colton's Practical Zoology, Sir William Dawson's Canadian Geology, Young's Elements of Astronomy, James's Psychology, and the Ontario Manual of Hygiene, together with twelve other subjects are all to be mastered in our poorly equipped academies in one or even in two years is to condemn absolutely the present arrangement with regard to Grade "A". It is but a survival from a lower stage of our educational development, and the sooner it is allowed to become atrophied by disuse the better.

If Academic and High School positions are worth on an average only ten years' tenure we will require but six new Grade A's each year,—say ten to give them the benefits of healthy competition, and let them have a thorough college training or its equivalent.

(*c*) The professional training of academic teachers and of the Principals of the larger schools should be part of a college course. Elsewhere at some length I gave my opinions on this subject. At present I will do no more than quote from an American educationist a few sentences which express the opinions of the most of our educationists and of our college graduates. "The environment of learning and culture are essential to the best training for the practice of the learned profession. * * * Existing normal schools, which have more than justified their establishment for the professional training of elementary teachers should continue to do their appropriate work. However much modified, they will not be well adapted to meet the wants of higher teachers."

Their professional training should be a post-graduate course at least in part. If our larger colleges cannot provide pedagogical training for the few Grade "A" teachers that we need we will have in the meantime no difficulty in obtaining it abroad; but wherever it is obtained let it be as thorough as the post-graduate training required in the other professions.

(*d*) Examinations in science, whether by the colleges or by the Educational Departments, should be so modified as to take into account the pupil's laboratory work throughout the term and his present ability to perform and interpret experiments, and also to examine and classify mineral, plant and animal specimens.

A certified copy of his Note-Book of experiments should be taken as evidence of his work. In order to have some reasonable certainty that this work was honestly reported it would be necessary for some qualified person to inspect the laboratories and see tbe students at work twice every year. A written examination does not adequately test a student's science acquirements. If the Provincial Grade "A" scientific examinations are to be continued they should be conducted at the Normal School, and every candidate should have to do a certain amount of laboratory work in the presence of the examiner.

Such are a few of the suggestions which I have to offer for the advance of science in Nova Scotia. I feel confident that if adopted

they will hasten the time when our reputation for science will not be confined to a few great names, but that all the people will reap the benefit in the opening up of new centres of those industries and manufactories for which the province is so well adapted.

The TREASURER presented the accounts for the year, 1897–8, which had been audited and were certified as correct. The following is an analytical statement of the expenditure :—

PROCEEDINGS AND TRANSACTIONS :—			
Printing and binding Vol. IX., Part 3	$158 00		
Less received for authors' separate copies	2 50		
		$155 50	
Distributing Vol. IX., Part 3		29 32	
			$184 82
Printing portion of Vol. IX., Part 4		$61 60	
Portrait and Plate, do		14 22	
			75 82
LIBRARY :			
Removal to Dalhousie College		$17 65	
Fittings		56 41	
Purchase of U. S. Government Reports		13 15	
Binding		75 00	
Miscellaneous expenses		8 20	
			170 41
Insurance (Library and Stock of Transactions)			16 75
Miscellaneous Printing, including Post Cards			25 00
Postage			5 67
P. O. Box			4 00
Advertising			4 00
Repairing and removing Blackboards			1 80
Typewriting			75
			$489 02

The Treasurer's Report was approved.

The Report on the Library was presented by the LIBRARIAN and CORRESPONDING SECRETARY. The Library had been increasing during the past year at a greater rate than ever before. The Institute had sent its Transactions for the first time to the following :—

Director-General de Correos y Telegraphos, Buenos Ayres.
Asociacion de Ingenieros Industriales, Barcelona.
State Library of Massachusetts, Boston.
St. Anne's College, Church Point, Digby Co., N. S.
Case School of Applied Science, Cleveland, Ohio.

High School, Dartmouth, N. S.
Scottish Meteorological Society, Edinburgh.
Institut Meteorologique Central, Helsingfors.
Cornell University (Geological Department), Ithaca, N. Y.
Royal Meteorological Society, London.
Institution of Electrical Engineers, London.
Kansas University, Lawrence, Ka.
Australasian Institute of Mining Engineers, Melbourne.
Kew Observatory, Richmond, G. B.
Royal Asiatic Society (Straits Branch), Singapore.
Public Library, St. Louis, Mo.
Anthropological Society of Australia, Sydney, N. S. W.
Catholic University of America, Washington, D. C.

Publications had been received for the first time during the past year from the following:

Société Belge de Geologie, Paleontologie et Hydrologie, Bruxelles.
Volta Bureau, Washington, D. C., U. S. A.
Australian Institute of Mining Engineers, Melbourne.
Carnegie Institute, Pittsburg, U. S. A.
Asociation de Ingenieros Industriales, Barcelona.
McGill University, Montreal.
Observatorio Meteorologico y Vulcanologico, Colima, Mexico.
Nederlandsche Dierkundige Vereenigung, Helder.
Institution of Civil Engineers of Ireland, Dublin.
Department of Mines, Wellington, New Zealand.
Engineers' Club of St. Louis, St. Louis, Mo., U. S. A.
Sydney Observatory, Sydney, N. S. W.
La Reale Academia de Ciencias y Artes, Barcelona.
Institution of Electrical Engineers, London.
Pasadena Academy of Sciences, Pasadena, Cal.
Wyoming Historical and Geological Society, Wilkesbarre, Pa.
Botanical Survey of India, Calcutta.

The Transactions were being sent out annually to 752 Societies, Museums, Libraries and Government Scientific Departments. Exchanges were being received from 440 Scientific Institutions. A considerable proportion of the 312 recipients of the Transactions from which exchanges had not yet been received were Libraries and Museums which did not issue publications of their own. A smaller proportion consisted of societies with which exchange relations had not yet been effected.

The cost of distributing the above 752 copies of our Transactions to institutions in all parts of the world had been $29.32, the possibility of securing so widespread a distribution at so small a cost being due to the courtesy of the Secretary of the Smithsonian Institution, Washington, in extending to the Institute the privileges of the Institution's Bureau of International Exchanges.

During the year, 113 volumes, for the most part English publications, had been put into the binder's hands. Including these, the Library now contained 1,326 volumes bound in cloth or leather, besides 67 volumes in boards with paper or cloth backs, in all 1,393 bound volumes. It contained besides, 271 volumes of sufficiently large size for separate binding, but at present simply stitched together in paper covers, as received, and a large number of volumes, at least 1,000 in Parts. The labour of looking into the completeness of these volumes in separate Parts, getting them completed when necessary, preparing them for the binder, and so on, is very great, and consequently in the case of many publications had not yet been undertaken. The Institute, as soon as funds will permit, should give the Librarian a paid assistant to do such work.

The Library had now been completely removed to the room at Dalhousie College, courteously offered free of rent by the Governors of that college. It had also been arranged in such a way that a visitor would have no difficulty in finding any work which the Library contained. The books are arranged under countries, labels and placards indicating the cases in which the publications of the various countries are to be found. In the division occupied by each country they are arranged under the cities which are the seats of the societies, museums, &c., from which they come, the cities being in alphabetical order. In the case of all publications in English, the shelves devoted to the various cities are indicated by labels giving the name of the city and the name of the society or other publishing body. The same system of labelling is to be extended to the publications in foreign languages at an early date. In any case in which the publications received from a society are too bulky for the shelf on which they would otherwise be placed, they are placed on the lowest shelf of the same division of shelving and the fact is indicated by a label on the shelf on which they would first be looked for, containing the name of the city and society and an arrow-head pointed downwards. It is hoped that with this system of arrangement members may find themselves able to get such books as they may desire without difficulty even in the absence of the Librarian.

The work connected with the arranging of the Library in its present quarters calls to mind the similar work which was done at the time when the Institute first really began energetically to build up its Library. The Proceedings contain no reference to the services rendered at that time by the late Mr. Denton, but though late, it is not too late to record the Institute's appreciation of them now.

The Library being in a room off the College Library will be found open by members daily, except on Saturdays and Sundays, from 10—1 and 3—5 o'clock. On Saturdays and in vacation, access to it may be obtained by members on application to the Janitor. Members resident in the country can ascertain whether such works as they may desire to see are in the Library, and have these which are, forwarded to them, by applying to the Corresponding Secretary. A printed catalogue would facilitate the use of the Library by members and should be undertaken as soon as the requisite funds are in hand.

The thanks of the Institute were presented to MR. BOWMAN for his services as Librarian, to the HON. ROBERT BOAK, President of the Legislative Council, for granting the use of the Council Chamber, to the CITY COUNCIL for the use of the City Council Chamber, and to the SECRETARY OF THE SMITHSONIAN INSTITUTION for his courtesy in continuing to admit the Institute to the privileges of the Bureau of International Exchanges.

Resolutions of regret were passed on the announcement of the deaths of PROFESSOR GEBELIN of the Society of Commercial Geography of Bordeaux, and of DR. EDWARD ALBERT BIELZ of the Society of Natural Science at Hermannstadt; and on the announcement of the resignation of PROFESSOR ALEXANDER AGASSIZ, Director of the Museum of Comparative Zoology, Cambridge, U. S. A.

The following officers were elected for the ensuing year (1898-99):—

President—ALEXANDER MCKAY, ESQ.

Vice-Presidents—A. H. MACKAY, ESQ., LL. D., F. R. S. C., and F. W. W. DOANE, ESQ., C. E.

Treasurer—W. C. SILVER, ESQ.

Corresponding Secretary—PROFESSOR J. G. MACGREGOR, D. SC.

Recording Secretary—HARRY PIERS, ESQ.

Librarian—MAYNARD BOWMAN, ESQ., B. A.

Councillors without Office—EDWIN GILPIN, JR., ESQ., LL.D., F. R. S. C.; MARTIN MURPHY, ESQ., D. SC., C. E.; WILLIAM MCKERRON, ESQ.; RODERICK MCCOLL, ESQ., C. E.; S. A. MORTON, ESQ., M. A.; WATSON L. BISHOP, ESQ.; P. O'HEARN, ESQ.

Auditors—G. W. T. IRVING, ESQ.; H. W. JOHNSTON, ESQ., C. E.

First Ordinary Meeting.

Legislative Council Chamber, Halifax, 14th November, 1898.

The President in the Chair.

A paper by Professor J. Davidson, Phil. D., of the University of New Brunswick, "On Statistics of Consumption and Expenditure in Canada," was read by Professor W. C. Murray. (See Transactions, p. 1).

The subject was discussed by Drs. MacKay and MacGregor, and Mr. Doane.

Second Ordinary Meeting.

Legislative Council Chamber, Halifax, 12th December, 1898.

The President in the Chair.

It was announced that Professor J. Davidson, Phil. D., University of New Brunswick, Fredericton, and Rev. Brother J. Peter, St. Joseph's Collegiate Institute, Buffalo, N. Y., had been elected Corresponding Members of the Institute; and that Andrew Halliday, Esq., M. D., Shubenacadie, N. S., and Arthur M. Edwards, Esq., M. D., F. L. S., Newark, N. J., had been elected Associate Members.

A paper by Dr. A. M. Edwards, entitled: "Infusorial Earths of the World, and the Iceberg Period," was read by Dr. A. H. MacKay.

Dr. A. H. MacKay gave an address on the subject of "The Diatomaceae of Nova Scotia." His treatment of the subject was a popular one, a number of microscopes with prepared slides being arranged for the convenience of their examination by those present. He called attention to the fact that these minute algae were characterized by the power of secreting silica from the waters in which they lived and building it up into the most beautifully formed and sculptured cell walls of transparent rock crystal; that they were so abundant in all of our fresh water lakes, which are not seriously disturbed by the turbulent earth laden waters of spring freshets, as to form layers many feet in depth in their bottoms of the dead silicious cells, the mass being sometimes so pure as to look like the whitest flour when dried; that this material was of commercial value in the manufacture of dynamite, of water-glass, tooth powders, scouring material of great fineness, firebrick,

etc. He noted that these deposits in lakes on different sides of the same watershed were characterized by the presence in more or less abundance of some peculiar species. He was endeavoring to obtain sections of some of these deposits so as to be able to compare the variation of or succession in the species since the first deposits were laid on the barren beds of the lakes carved out in the glacial period. Over a hundred different species had already been observed in our fresh water deposits, many of them identical with those found in similar deposits in the Eastern hemisphere. Among them were found the silicious spicules of several species of freshwater sponges, which appear to be also more or less abundant in all our freshwater deposits. The following species of diatoms have been already identified in these deposits :

Cocconeis pediculus, *Ehr.* C. placentula, *Ehr.* Gomphonema acuminatum, *Ehr.* G. a, *var.* coronatum, *Ktz,* G. a. *var.* laticeps, *Ehr.* G. cristatum, *Ralfs.* G. gracile, *var.* naviculoides, *Grun.* G. abbreviatum, *Ag.* G. capitatum, *Ehr.* G. intricatum, *Ktz.* G. cistula, *Hemper.* Epithemia turgida, *Ehr.* E. gibba, *Ehr.* E. g. *var.* parallela, *Grun.* E. argus, *Ehr.* Himantidium arcus, *Ehr.* H. a. *var.* majus, *W. Sm.* H. a. *var.* tenellum, *Grun.* H, formica, *Ehr.* H. pectinale, *Ktz.* H. p. *var.* ventricosum, *Grun.* H. p. *var.* minus, *Ktz.* H. p. *var.* undulatum, *Ralfs.* H. soleirolii, *Ktz.* H. bidens, *W. Sm.* H. b. *var.* diodon, *Ehr.* H. praeruptum *var.* inflatum, Grun. H. polydon, Brun. H. polydentulum, *Brun.* Amphora ovalis, *Ktz.* A. affinis, *Ktz.* Cymbella gastroides, *Ktz.* C. cuspidata, *Ktz.* C. ehrenbergii, *Ktz.* C. lanceolata, Ehr. C. delicta, *A. Sch.* C. cistula, *Hemper.* C. heterophylla, *Ralfs.* C. tumida, *Ktz.* N. ambigua, *Ehr.* N. appendiculata, *Ktz.* N. affinis, *var.* amphirhyncus, *Ehr.* N. firma, *Grun.* N. Hitchcockii, *Ehr.* N. legumen, *Ehr.* N. dicephala, *Ktz.* N. radiosa, *Ktz.* N. scutellum, *O'Meara.* Pinnularia oblonga, *Rab.* P. viridis, *Rab.* P. v. *var.* hemiptera, *Rab.* P. perigrina, *Ehr.* P. nobilis, *Ehr.* P. major, *Rab.* P. dactylus, *Ktz.* P. gibba, *Ehr.* P. divergens, *W. Sm.* P. interrupta, *W. Sm.* P. mesolepta, *Ehr.* P. nodosa, *Ehr.* Stauroneis phoenicenteron, *Ehr.* St. gracilis, *W. Sm.* St. anceps, *Ehr.* St. fulmen, *Breb.* St. punctata, *Ktz.* St. stauropheria, *Ehr.* Surirella robusta, *Ehr.* S. splendida, *Ehr.* S. biseriata, *Breb.* S. bifrons, *Ktz.* S. turgida, *W. Sm.* S. linearis, *var.* constricta, *W. Sm.* S. slevicensis, *Grun.* S. elegans, *Ehr.* S. tenera, *Grey.* S. cardinalis, *Kitton.*

Nitschia amphioxys, *Ehr.* N. elongata, *Grun.* N. spectabilis, *Ralfs.* N. sigmoidea, *Nitzsch.* Stenopterobia anceps, *Breb.* Fragillaria construens, *Grun.* F. c. *var.* binodis, *Grun.* F. capucina, *Desm.* F. undata, *W. Sm.* Synedra ulna, *Ehr.* Meridion circulare, *Ag.* Tabellaria floculosa, *Roth.* T. fenestra, *Lyngb.* Cyclotella operculata, *Ag.* C. comta *var.* affinis, *Grun.* Melosira distans, *Ehr.* M. arenaria, *Moor* M. orichalcea, *Meriens.* M granulata, *Ehr.* M. crenulata *var.* valida *Grun.*

A vote of thanks was tendered DR. MACKAY for his address.

THIRD ORDINARY MEETING.

Legislative Council Chamber, Halifax, 9th January, 1899.

The FIRST VICE-PRESIDENT, DR. MACKAY, in the chair.

LEE RUSSELL, ESQ., B. Sc, of the Normal School, Truro, read a paper on "School-room Air," as follows :

One of the great problems of modern mechanics is to increase the efficiency of machines, to get the greatest amount of work done with a given expenditure of energy. Every possible device is used to lessen friction, to minimize waste, and to apply more advantageously the force employed. Rails in place of the uneven ground, rolling, instead of sliding, friction, are familiar examples of the gains made in the single direction of lessening friction, and many more might be instanced. These are purely physical instances, but the illustration may be carried further. Intellectual processes are as subject to waste and loss. Interruption, noise, disease, poisons, are the causes of loss in mental operations, as are dust, friction, inertia, and radiation, in those of a physical nature. Such considerations as these first led me to investigate some of the causes of decrease of efficiency in school.

It appears to me plain, that as the school year advances, there is a decrease in mental power in both teachers and pupils. By this is meant, that for a given result, more energy must be expended toward the close of the year than at the beginning.

This is not susceptible of exact proof, except by long and carefully conducted experiments, but from observations made upon the students at the Normal School at Truro I believe such to be the case.

It is well known that the exhalations from the bodies of animals have a poisonous effect if breathed, even tho much diluted with air. The classic researches of Pettenkofer, Brown-Séquard, d'Arsonval, Lehman, Merkel, Parkes, and others, have proved the presence of an organic poison in air which has been breathed by man or other animals. Its exact constitution is not known, but the effects of "Pettenkofer's man-poison" are apparent in every school-room. They are, headache, drowsiness, slight fever, and a general retardation of all reactions to stimuli. Partial loss of the power of inhibition is also noticeable. Less apparent, but more important, are the general weakening of vitality and the greater susceptibility to disease which follow prolonged breathing of impure air.

These effects are more easily seen in the weak and anaemic than in vigorous persons. It was the observation of the less vigorous students at Truro which first led me to suspect that the air in the Normal School might be one cause, at least, of the decrease in power which I had noticed. We have, as do all schools, pupils who, when at their best, are just able to keep up with the class, who are, mentally or physically, near the *fatigue-point.* A slight interference with their normal activity throws them off their balance, and they must drop behind. Not infrequently pupils come to us enfeebled by excessive study in preparation for examinations. Under favorable conditions they might do well, but if subjected to further strain they may break down. With these two classes of students, poisoning by impure air may make the difference between success and failure. At all times, and with all classes, it causes a determinable decrease in the amount of work, mental or physical, which is done with a given expenditure of energy. Especially where the system of public education is most highly developed and most strenuously applied, the evil effects of this poison have been most apparent.

In testing the air in the Normal School, the method and apparatus of Prof. Hch. Wolpert of Nuremburg was adopted. The chemical basis of this method is the fact that an alkaline solution of sodium carbonate becomes neutral by the absorption of carbon dioxid. If the alkaline solution be colored red by phenol phthalein, when the solution becomes neutral the color disappears. Thus, with a given amount of sodium carbonate, the decolorization of the liquid shows that a certain amount of carbon dioxid has been absorbed. If this carbon dioxid come from a

measured quantity of air, the proportion of carbon dioxid in the air is easily calculated. Carbon dioxid is a constituent of all air, but it has been shown that in re-breathed air it increases in direct proportion to the other, more poisonous, but less easily detected, impurities. We shall therefore make no error if we use the amount of carbon dioxid as an indicator of the amount of the organic poisons.

The apparatus is so arranged as to admit into a glass cylinder which contains a measured amount of the standard solution, the air to be tested. When enough has been admitted to neutralize the solution, the proportion of carbon dioxid may be read off from a scale etched on the glass.

It should be stated that as checks upon the experiments, samples of air were tested by other methods, the results agreeing very closely with those obtained by the Wolpert method. This is not as exact as systematic chemical analysis, but it is sufficiently so for the purpose.

The instrument is graduated for 0°C and 760mm. of mercury pressure. As the air tested was always at a temperature of from 15°C to 20°C, and as the average pressure at Truro is 761mm., there should be about 7% added to the actual observations to correct them for temperature and pressure. I give below a table showing a set of observations which were made in the Chemical Laboratory at the Provincial Normal School. They are corrected for temperature and pressure, and the conditions in the room at the time of the various tests are given as accurately as possible.

TESTS OF THE AIR IN THE CHEMICAL LABORATORY, PROVINCIAL NORMAL SCHOOL, TRURO, NOVA SCOTIA.

Date.	Time.	Condition of the Laboratory.	CO_2 (parts in 10,000.)
Mar.	A. M.		
7	9.00	Empty	6.42
14	9.00	"	4.28
15	9.00	"	3.21
21	9.00	"	4.28
22	9.00	"	16.05
24	9.00	"	6.42
17	9.45	34 students—40 m.—high wind	9.63
22	9.45	32 " " windows open	16.05
8	10.00	" " 1 h.	20.33
15	10.00	" " " windows open	9.63
22	10.00	" " " windows and doors open	16.05
8	10.40	" " 1 h., 40 m., windows and doors open	23.54
9	10.40	" " "	21.40
15	10.40	" " " windows open	10.70
17	10.40	" " 1 h.	16.05
9	12 m.	" " " windows open	20.33
16	12 m.	" " " "	17.12
21	12 m.	" " 1 h., 15 m., Blow-pipe lamps in use	48.15
23	12 m.	" " " windows open	17.12
	P. M.		
7	5.00	Empty	16.05
10	5.00	"	20.33
26	5.00	"	42.80
27	5.00	Laboratory used for blow-pipe work in mineralogy for 1 h., 45 m., by 20 students	65.00

The observations made in the Laboratory were chosen for presentation because they present,

1. A mean between the worst and best rooms in the building.
2. A greater variety of conditions than any other room.
3. A large air space per pupil—9 cu.m., or 318 cubic feet.
4. Less interference from other rooms, and from interruption during the test.

The month of March was chosen because at that time the laboratory work consists of lectures and blow-pipe analysis, where few chemical re-agents are used and those mostly in the "dry" state. With one exception, March 21, no blow-pipe work was done till after 3 o'clock in the afternoon. Moreover, March presents many warm days when it is possible to have windows open, while in the winter the insufficiency of our heating apparatus is such as to make this impossible. It has been

my endeavor to present a case considerably better than the worst which obtains in our school.

As will be seen, a great variety of conditions is presented. The use of the room is intermittent, and when in use, its ventilation depends wholly upon the temperature of the outside air. The heating apparatus is so inadequate that upon a cold day with all windows closed the temperature cannot be brought above 62° F. Hence it is only during comparatively warm weather that the windows can be opened at all.

The laboratory gives an air space of nine cubic meters to each of thirty-four students, due allowance being made for the desks and cases.

All authorities admit that air containing more than six parts of carbon dioxid in ten thousand is injurious, but for various reasons it is generally agreed that Pettenkofer's standard of ten parts of carbon dioxid may be used as the outside limit for ordinary school-room air. For kindergartens it is thought that the air should never become more impure than is indicated by the presence of four parts of carbon dioxid in ten thousand. It will be seen that only at the beginning of school does the air in the laboratory come within Pettenkofer's standard.

From all observations made in all the rooms in the Normal School, and in the corridors, the times of making the tests being from 9 a. m. to 5 p. m., and the conditions as various as exist in any school building, and the dates from March 6 to June 1st. I find the following averages for the amount of carbon dioxid in ten thousand parts of air:

At 9.00 a. m.	8.30
" 9.40 "	9.63
" 10.00 "	20.33
" 11.00 "	16.05
" 12.00 m.	23.54
" 3.15 p. m.	18.19
" 5.00 "	29.96

The decrease in impurity from ten to eleven o'clock is due to the recess taken by the model school at that time. The great increase after 3.15 is more difficult to account for, but it seems to me satisfactorily explained by these considerations. 1st. During school hours the warm air breathed out rises, so that even the heavy carbon dioxid is carried upward. When the whole air cools the carbon dioxid is found near the floor. 2nd. After school, much blow-pipe work was going on in the laboratory, raising the impurity in that room, and the library was usually crowded. The average of many five o'clock tests in the latter room gives forty-five parts of carbon dioxid in ten thousand of air.

A consideration of these figures will make it evident that we are severely handicapped in our work at the Normal School, and that pupils and teachers are, in a greater or less degree, poisoned by the air in the school building.

This is in no way a peculiarity of the Normal School. With the exception of some modern ventilated buildings in Halifax, and in a few of the towns, all schools are just as bad. I have found most country schools which I have visited with just as impure air as that at Truro.

The amount of air space per pupil in the various rooms in the Normal School is much greater than that in most schools. Six cubic meters per pupil is considered ample, and in no room at Truro, except the library, have we less than seven.

The obvious remedy here is to provide some means of changing the air. With the present heating it is impossible to do this by means of windows, even if there were no danger from drafts by such a mode of ventilation.

The really important problem to be solved is the ventilation of the country schools. Here are the greatest numbers, at ages when injury is very dangerous, since it may effect the whole future life of the pupil. That we may do the "greatest good to the largest number" by ventilating the country scnool houses is evident. The obstacle in our way here is the complete ignorance of the people of the principles of ventilation. This is perfectly excusable, since it is only within comparatively few years that the subject has been studied at all. A "campaign of education" is feasible, but is expensive. The Inspectors are the proper persons to bring the matter before the teachers and the trustees. The Department of Education can also do much by securing plans of suitable buildings and requiring all new school houses to be built upon one of these plans. They may be of various sizes and prices so as to suit the needs of poor or of wealthy sections. Thus, in time, every school-house in the Province would be provided with pure air, and the cost be saved many times over by the increased efficiency of both teachers and pupils. Until something is done by the central authority in some such compulsory manner as I have indicated, I fear there will be no change.

As for the Normal School, the only remedy for the state of affairs existing there is to provide the building with suitable heating and ventilation.

The paper was discussed by the Chairman, MESSRS. O'HEARN, MCKERRON, DOANE, BLACKADAR, HOPSON, BAUSCH and PROFESSOR E. MACKAY.

A vote of thanks was presented to MR. RUSSELL.

FOURTH ORDINARY MEETING.

City Hall, Halifax, 13th March, 1899.

The PRESIDENT in the chair.

EDWIN GILPIN, JR., ESQ., LL. D., F. R. S. C., read a paper, entitled, "New Mineral Discoveries in Nova Scotia." (See Transactions, p. 79.)

A. P. REID, ESQ., M. D., exhibited and explained a model of a Sanatorium for Consumptives.

A vote of thanks was presented to DR. REID for his communication.

FIFTH ORDINARY MEETING.

Legislative Council Chamber, Halifax, 17th, April, 1899.

The PRESIDENT in the chair.

It was announced that at the last meeting of the Council, HERBERT E. GATES, ESQ., Architect, Dartmouth, and WILLIAM A. MACDONALD, ESQ., Halifax, had been elected ordinary members.

PROFESSOR J. G. MACGREGOR, D. SC., read a paper entitled, "On finding the ionization of complex solutions of given concentration, and the converse problem. (See Transactions, p. 67).

A paper entitled, "Phenological Observations, Canada, 1898," was read by A. H. MACKAY, ESQ., LL. D., F. R. S. C. (See Transactions, p. 91.)

Sixth Ordinary Meeting.

Legislative Council Chamber, Halifax, 8th May, 1899.

The President in the chair.

A circular from the Royal Society of Canada, relative to the appointment of a delegate to the forthcoming meeting, was read and referred to the Council for action.

Prof. J. G. MacGregor communicated a "Note on the variation with tension, of the elastic properties of vulcanised india-rubber," being an account of some experiments made in his Laboratory at Dalhousie College, by Mr. W. A. Macdonald.

The experiments had been intended originally to deal with rigidity only, but it had been found possible to apply some of the observations to the determination of Young's Modulus as well.

The composition of the specimen of india-rubber used was not known. It was in the form of a cylindrical cord and was fairly soft in texture and grey in color, a freshly cut surface having a mottled appearance. It had been obtained from Messrs. Thornton & Co., Edinburgh, and was both very true and very uniform in its circular cross section.

The method employed for determining the rigidity under tension was the method of oscillation. It was necessary therefore to fix the upper end firmly and to attach a weight-holder firmly to the lower end. As the problem had been assigned to Mr. Macdonald as a class exercise merely, and no appropriate gear for the attachment of the ends was immediately available, he had to be contented with a makeshift method. He drew the ends of the cord through pieces of glass tubing, previously coated internally with soft sealing wax, of considerably smaller diameter than the cord, and then gently heated the tubes until the wax melted. The tube at the upper end was fixed to a bracket, that at the lower end carried a cork disc which served as a weight-holder. To reduce the error due to lack of uniformity in the diameter of the cord near the ends, produced by the pressure of the tubes, the cord selected for use was a long one. Except in so far as the heating may have changed the physical properties of the cord near the lower end, the arrangement was satisfactory enough for the comparatively small extensions for which it was intended. But for the greater extensions, to which the earlier results made it appear desirable to proceed, it was not suitable. For

under considerable stress the wax near the ends of the glass tubes gave way, and the space thus left in the ends of the tubes had to be packed to make it certain that the portion of the cord actually subjected to tension and torsion was the portion outside the tubes. The observations under the greater stresses are thus considerably less trustworthy than the others.

The weights used were square plates of sheet lead with an edge of four inches, having a small circular portion cut from the centre, and a slit from the centre to the edge to admit of their being placed on the holder. Their moment of inertia could therefore readily be calculated. The length of the cord was measured by means of a beam compass, reading to .01 inch, and its diameter by a micrometer gauge reading to .001 inch. The time of oscillation was determined by means of a stop-watch reading to 0.2 second. The observations given below were in all cases means of several individual observations,—the length and radius of five, and the times of oscillation, of ten. No special effort was made to keep the cord at constant temperature; but the temperature of the laboratory varied but little.

The course of the observations was determined by Mr. Macdonald's available time rather than by the fitness of things. He kept the cord stretched slightly throughout the whole series by 482 grm., and from time to time he would apply additional weights, make the requisite observations, and then remove such additional weights, the observations requiring perhaps a couple of hours. The dates of the observations are given in the table below. Unfortunately the length of the cord under its permanent stress was not in all cases, and its diameter was in no case, determined immediately before the application of the additional weights, such observations not being necessary for the purpose originally in hand.

The following table gives the results of the observations and the calculated values of the rigidity. The observations have been reduced to C. G. S. units, and the rigidities expressed in absolute units of that system. The rigidities were calculated from the formula:

$$n = \frac{8 \pi l I}{r^4 t^2},$$

where n is the rigidity, l the length, and r the radius, of the cord, I the moment of inertia of the lead plates, and t the time of a complete oscillation. In finding the moment of inertia the weight-holder of cork and glass was neglected, as also the small circular apertures in the lead plates. The volume of the cord is given in the table also.

Date.	Temperature, (°C.)	Length, (cm.)	Radius, (cm.)	Weight appended (grm.)	Time of oscilla. (sec.)	Volume of cord, (c. c.)	Rigidity, (abs. C, G. S. units). $10^6\times$
			First Series.				
Mar. 16	15.6	90.68	.....	482	......	......	......
21	18.1	90.98	0.356	482	10 80	36.03	10.18
21	.....	96.60	.343	735	16.00	35.69	8.68
22	17.5	91.24	......	482	......	......	......
22	17.6	103.99	.335	981	20.04	36.73	8.69
23	18.7	91.51	......	482	......	......	......
23	18.9	113.92	.323	1222	25.32	37.25	8.67
28	18.6	92.35	......	482	......	......	......
28	18.6	123.21	.307	1467	29.76	36.57	9.89
Apr. 4	18.8	137.41	.293	1714	35.88	37.16	10.68
5	19.3	138.38	.293	1714	36.36	37.42	10.48
6	17.7	150.37	.279	1956	40.80	36.88	12.54
			Second Series.				
Apr. 13	17.0	95.65	.345	482	12.22	35.86	9.38
13	17.4	102.16	.337	735	18.44	36.36	7.44
13	17.5	110.31	.324	981	23.80	36.35	7.51
13	18.0	121.13	.312	1222	29.26	37.15	7.85
20	......	130.97	.301	1467	33.64	37.28	8.95
20	......	141.83	.290	1714	38.48	37.36	10.10
20	.....	151.99	.282	1956	42.30	37.96	11.37

The first series of observations showed that the rigidity, as determined, at first diminished with tension, then reached a minimum value, and finally increased, as the cord was more and more stretched,—an interesting result if it should be substantiated. Hence a second series of

observations was made with the same cord and the same arrangements as the first. This series had to be made somewhat hurriedly, as will be seen by the dates of the individual experiments, but the experiments were made with the same care as those of the first series. It will be seen from the above table that (1) the treatment to which the cord had been subjected in the first series had diminished its rigidity, the values being smaller throughout than in the first series, and (2) that the initial diminution of rigidity with increase of tension, its final increment with tension, and the occurrence of a minimum point are as marked in the second series as in the first.

To find out if the occurrence of the minimum point was due to the defective character of the attachments at the ends of the cord, Mr. Macdonald made a number of observations with new modes of attachment. These consisted of brass tubes in one end of which three longitudinal cuts had been made, the ends of the three strips thus formed being bent inwards and provided with teeth. The ends of the cord having been passed into these tubes, the strips were firmly bound to the cord by means of wire. Unfortunately Mr. Macdonald had not sufficient time to make more than rough observations with the new arrangement. Such observations as he was able to make seemed to show that the minimum point had disappeared. Whether its disappearance was due to the more satisfactory attachments, the passing away of the heating effect or the fatigue of the cord, Mr. Macdonald hopes to determine by further experiments.

The above values of the rigidity agree fairly well with Mallock's[1] determinations, Mallock having found that the rigidity of what he calls "soft grey" india-rubber, determined dynamically, ranged from 5.52 to 8.76, if expressed as in the above table, and that for "hard grey" rubber it ranged from 10.77 to 13.94. Mr. Macdonald's rubber could not be designated as either soft or hard; and his values are intermediate between Mallock's for the soft and the hard specimens.

The volume of the cord underwent very little change during either the first or the second series. In both series, however, there is an unmistakeable though small increase of volume with stretching; but whether it was due to the stretching or to the series of oscillations to which the cord had been subjected does not of course appear.

---

[1] Proc. R. S. Lond., 46, 233, 1889.

Mr. Macdonald did not intend at the outset, to make any determinations of Young's Modulus; but his observations may be used for two purposes, viz., to determine (1) how the value of this modulus for a cord under a constant original stress varies with the magnitude of the increment of stress to which it is subjected, and (2) how the value of the modulus for a cord under different original stresses, and elongated by approximately equal increments of stress, varies with the magnitude of the original stress. In the determinations given below, Young's Modulus has been taken to be the increment of tensile stress divided by the corresponding increment of length per unit of the length immediately before the stress was increased.

(1) The observations requisite for the first purpose were made only in a few cases; and even in those cases in calculating the increment of tensile stress, it is necessary to assume (the requisite measurements not having been made) that the radius of the cord would not appreciably vary with the small variations of length under the permanent load—an assumption which is doubtless permissible. The following table gives the results :—

Original Stress (grms. per sq. cm.)	Additional Stress (grms. per sq. cm.)	Elongation per unit length.	Young's Modulus, (abs. C. G. S. units). $10^6 \times$
1354	789	.0618	12.53
1354	1574	.1397	11.05
1354	2529	.2449	9.73
1354	3424	.3342	10.05

These determinations would thus seem to show that for the smaller additional stresses to which the cord was subjected, the value of Young's Modulus diminished as the additional stress increased, that for the larger additional stresses, it increased with the additional stress, and that there was a certain additional stress for which Young's Modulus had a minimum value,—this additional stress being of such a magnitude as to produce an elongation of about 0.25. This result is in agreement, qualitatively, with Mallock's observations, which showed that Young's Modulus, statically determined, " diminishes with the extension until the stretched length is about 3/2 times the natural length." As Mallock's

rubber no doubt differed in degree of vulcanisation from Mr. Macdonald's, and as he used a different initial stress, it is not surprising that the elongations giving a minimum value for Young's Modulus should be 0.25 in the one case and 0.5 in the other.

Mallock's mean value of Young's Modulus, when expressed in absolute C. G. S. units, was 8.56×10^6 for soft grey india-rubber, and 34.16×10^6 for hard grey rubber. As in the case of the rigidity, Mr. Macdonald's values are intermediate, being nearer Mallock's values for the soft than for the hard specimen.

(2) The following table contains the determinations made for the second purpose mentioned above.

Original Stress (grms. per sq. cm.)	Additional Stress (grms. per sq. cm.)	Elongation per unit length.	Young's Modulus, (abs. C. G. S. units). $10^6\times$
FIRST SERIES.			
1354	789	.0618	12.53
2143	785	.0765	10.06
2928	855	.0955	8.78
3783	995	.0816	11.97
4778	1072	.1152	9.13
5850	1161	.0943	12.08
SECOND SERIES.			
1397	784	.0681	11.30
2181	847	.0798	10.42
3028	889	.0981	8.89
3917	957	.0812	11 55
4874	1036	.0829	12.26
5910	1026	.0716	14.05

It will be seen that in both series of observations the values of the modulus are large at the outset, diminish in value as the original stress is increased, reach a minimum value and thereafter increase with the original stress. The irregularity of the fourth and fifth determinations in the first series, is obviously due to the unusually long intervals of time which, as the first table, p. xxx, shows, intervened between the two pairs of observations on which they are based. The variation of Young's Modulus with initial stress, the additional stress being roughly constant, would thus appear to be similar to that which was shown above to hold with respect to additional stress when initial stress is constant.

It should be noted, with respect to all the above determinations of Young's Modulus that the values found apply to the state of the cord immediately after the application of the additional stress, and in addition that the cord was subjected to torsion after each observation of length.

Mr. Macdonald hopes to be able to continue the above investigation at a later date.

The paper was discussed by Dr. Murphy.

James Barnes, Esq., B A., Dalhousie College, read a paper "On the Conductivity, Specific Gravity, and Surface Tension of Aqueous Solutions containing Potassium Chloride and Sulphate." (See Transactions, p. 49.)

Harry Piers, Esq., read a paper entitled, "Observations on a Fish new to the Fauna of Nova Scotia." (See Transactions, p. 110.)

Charles F. Lindsay, Esq., read a paper "On the presence of Acid Sulphates in Solutions containing Copper Sulphate and Sulphuric Acid."

The paper was discussed by Professors E. MacKay and MacGregor, and Dr. A. H. MacKay.

A vote of thanks was presented to Messrs. Macdonald, Barnes and Lindsay for their communications.

The following paper was read by title: "Notes on Nova Scotian Zoology: No. 5," by Harry Piers, Esq.

The Council was authorized to receive as read by title, any papers that might be offered too late for this meeting.

HARRY PIERS,
Recording Secretary.

PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1899-1900.

ANNUAL BUSINESS MEETING.

Legislative Council Chamber, Halifax, 20th November, 1899.

The PRESIDENT, ALEXANDER MCKAY, ESQ., in the chair.

The PRESIDENT addressed the Institute, as follows :—

GENTLEMEN,—A review of the last year's work of this Institute may well be very brief. Meetings were held at the usual times, except in February, on account of a severe storm. Twelve papers were read and discussed, and another was read by title. These cover a wide range of subjects: Social science, geology, sanitary science, mineralogy, medicine, chemistry and botany, zoology and physics.

Prof. Davidson, of the University of New Brunswick, opens up a field new to the Institute by a valuable paper "On Statistics and Expenditure in Canada." In this and related studies there are splendid opportunities for unlimited research and the display of the highest order of talents. A paper by Prof. Russell on "School Room Air" will be of much interest and value to teachers. The tests recommended are inexpensive, and such as can be generally used. Teachers who have once made these tests will ever afterwards be more alive to the almost criminal carelessness of those who allow children to occupy badly-ventilated school rooms. Dr. A. P. Reid also deserves the

thanks of the Institute for calling attention to the spread of consumption by contagion and its prevention by means of properly constructed sanitaria, of which he exhibited a model. In the phenological observations of the school children, collected by Dr. MacKay, and in the experiments in physics and chemistry conducted by Messrs. Barnes and Lindsay—promising young students of Dalhousie College—we see hopeful signs of a reviving interest for science in Nova Scotia. Mr. Piers has favored us with "No. 5 of Notes on Nova Scotia Zoology." Dr. Mackay, who is our only authority on the Diatomaceæ of Nova Scotia, has awakened a fresh interest in one of his favorite studies by another paper reporting progress, and by exhibiting excellent microscopic slides of our principal diatoms.

Upon the whole, then, the work of the year has been of very considerable interest and of some scientific importance.

We have added to our numbers two ordinary members, one corresponding member and three associate members. We record with sorrow the death in September of one of our oldest and most faithful members, Mr. J. J. Fox. He was born in Salisbury, England, in 1818. He studied medicine, but preferred a seafaring life, and spent many years full of adventure in Egypt, Greece, the West Indies and South America. In 1852 he was appointed by the Imperial Government comptroller of customs and navigation laws at Magdalen Islands.

A faithful performance of duties soon led to advancement, and for many years he was familiarly known as "governor." He was characterized by modesty, bravery and humanity. For valuable services to shipwrecked mariners he was presented by the President of the United States with a magnificent gold watch valued at $1,000. His intimate knowledge of the fisheries made him a most valuable witness before the Halifax fishery commission in 1877. After retiring from the civil service he lived in Halifax, joined the Institute, and seldom missed a meeting.

To-day brings us sad tidings of the death yesterday of Sir William Dawson, the most distinguished member of our Institute and the most eminent scientific man in Canada. He was born in Pictou in 1820. At a very early age he began his studies in natural history, thereby cultivating his powers of observation, and thus laying the foundation for his remarkable achievements in geology subsequently. His success in this respect is a good argument in favor of the early introduction into our course of study of science teaching.

Mr. Dawson graduated from Edinburgh University at the age of 26. For four years he studied geology, travelling part of the time with Sir Charles Lyell, the greatest geologist of the world. At the age of thirty he was superintendent of schools for Nova Scotia, and did much to lay the foundation of our present educational system. In 1855 he was appointed Principal of McGill University, a position which he held until 1893, until he and the University had become famous the world over.

He was capable of a prodigious amount of hard work. In his favorite science he kept in the foremost rank, but he found it difficult to avail himself of the light thrown upon natural phenomena by the theory of evolution of which he was a most uncompromising opponent.

His extraordinary industry is shown by the large number of books and scientific articles which he wrote. Some of them were of very great value and are still used as text books.

His eminent services to science were acknowledged by his appointment as first President of the Royal Society of Canada in 1882, his election in the same year as President of the American Geological Association, and of the British Association in 1886. He received honorary degrees fram various universities, and was knighted in 1884.

At the close of my address last year I referred to the fact that science was much neglected or very badly taught in our schools. As a remedy I suggested (a) that the colleges prescribe science as a subject for matriculation, (b) that for the academic license more scholarship, especially in practical science, and a long course of the best professional training be made imperative, (c) that higher qualifications in science be required for B licenses, and (d) that a large part of the provincial examination in science for grade A consist of laboratory work.

The progress of science teaching in other countries during the last year has all been in confirmation of the soundness of these principles. No doubt the time is near when we also must adopt them. When that day comes, and not until then, science will make satisfactory progress in all our educational institutions.

But it is perhaps more especially the province of this Institute to awaken the public to an interest in general science and to stimulate and assist individuals in particular fields of research.

In reference to this aim I may be allowed to make some additional suggestions :

1. We should have a scientific library easily accessible to scientific workers in every part of the Province. At present we have nothing of the kind. A collection of partially catalogued, somewhat inaccessible reports of scientific societies cannot be said to be such a scientific library as the majority of workers need, however useful it may be to those engaged in original research.

We require not less than 5,000 volumes of the latest books by the ablest men of science ; 10,000 would be better. In addition to this there should be complete sets of all the scientific periodicals in English, French and German.

Such a collection of standard science textbooks, supplemented by government reports on agriculture, forestry, fisheries, etc., and the reports of scientific societies, and managed by a competent librarian, would be of incalculable benefit. I have no hesitation in saying that I believe it is the duty of our government in its encouragement of technical instruction to establish such a library. If there existed an intelligent appreciation of its value the cost would not long be a hindrance, for the number of books required would not be large, and probably many of them would be received as donations.

But why should the government provide a science library any more than a law library or a historical library ? Because science in some form or other lies at the foundation of success in all the industries of the country, so that the government would be justified and supported in making an expenditure which would result in such general benefit. Facilities for scientific research would lead to discoveries which would pay the cost a thousand fold. Pasteur's discoveries were worth untold millions to France.

Although Nova Scotia is not large, populous or rich, yet her natural resources are so great and varied as to warrant the government in following the examples of other countries in respect to technical education; and the establishment of a good science library would be but the first and most natural step in that direction.

Recently I wanted to consult twenty or thirty scientific works and periodicals. In the three largest public or quasi-public libraries of Halifax I was able to find but one of them. No wonder that our ablest young men are lost to the Province when we deny them the opportunities for research which they readily obtain elsewhere.

Here let me call your attention to the most valuable and self-sacrificing labors of Dr. MacGregor and Mr. Maynard Bowman in connection with the library of this Institute. A few years ago, when they began work upon it, it consisted of a small number of unclassified reports from secieties in various parts of the world. It now includes a large number of serial publications by scientific societies and other institutions, and numbers about 1,500 bound volumes with about as many more unbound. These haee been placed in a room temporarily provided by Dalhousie College, and so arranged that any one desirous of consulting any volume would be able to find it without the assistance of the librarian.

The work of bringing order out of the confusion that existed at first, the cataloguing and labelling of so many books, searching and sending abroad for missing numbers, was an immense labor, which if performed by a paid expert would have cost several hundred, not less, perhaps, than two thousand dollars.

But in addition to all this, the addresses of other societies had to be searched and copies of our Transactions sent abroad to about 700 societies in all, by which means the number of valuable publications received each year was more than doubled. Surely when these two gentlemen have done so much, we may expect our provincial government to supplement their efforts by the addition to this library each year of a few hundred treatises. Then would it not be better that the library thus enlarged should be taken over by the government, properly housed and managed, and made free to the public?

Nor must I forget to say that the thanks of this Institute are due to the Governors of Dalhousie College for the use of a room at a time when our library became so large that it could no longer be kept in the place which it formerly occupied.

2. A properly conducted museum would do much to popularize science in our midst. A collection of dusty, unlabelled, badly arranged specimens does not amount to much and scarcely justifies the expense. Such a museum is the deadest of all dead things.

To be practically useful a museum requires a large, well-lighted, readily accessible room. It should primarily contain typical specimens of the most important natural bodies, arranged according to their chemical or organic affinities, so that the student may learn from them at a glance something of their relationship and the laws of nature

Especial attention should be given to the products of this Province. They should be scientifically marshalled and their industrial applications carefully and suggestively illustrated. Raw products in every stage of their manufacturing processes should be exhibited.

The museum should be in charge of a man of the broadest scientific culture, a man of business capacity, and a thorough teacher.

A museum thus equipped would do more for science than any college or any other agency. Every visitor from the country would return to his home with his curiosity awakened, and often with scientific problems or difficulties solved, with a new inspiration for further advances.

Such an institution would have organic connection with every high school and college in the province, exchanging specimens and thus enriching the local school museums, diffusing scientific information, and stimulating scientific activity.

How often throughout the last sixteen years have our teachers lamented the want of opportunity in this respect? During their holidays they would have made large collections of interesting objects which they would study in classes formed at the museum. Long since every school in the city, after the example of the German schools, would have been supplied with a respectable collection of labelled specimens for the instruction of their pupils, and the amount of scientific knowledge and interest would have been increased tenfold.

For the sake of economy and efficiency the museum and the science library should be in the same building and in charge of the curator of the museum.

Book and specimen are complementary and should be drawn as close together as possible. "First of all, their aims are identical, for they have the one end in view, the culture of the people ; secondly, they appeal to the same mental faculties with which all men are endowed in a greater or less degree, and thirdly, to a very great extent one of them, the museum, to carry out its proper functions to a great measure, is dependent on the other. It leans upon it, as it were ; it looks to it to minister to the museum visitors that information which the most comprehensive catalogue and labels in the world would fail to supply."*

If all the specimens were labelled giving references to the books in which they were best described, placed on a shelf near at hand, the

---

* **C. W. Wallis, Curator Birmingham Art Galleries and Museum.**

student's ability to do better work and the extent to which both library and museum could be utilized would be greatly increased. The tendency in England, Ontario and the United States is towards combining libraries and museums in the same building.

In conclusion, when the colleges come to see that good work in science in the high school gives, to say the least, as valuable mental discipline as classics, aud vastly more of useful knowledge; when the education department provides adequate professional training for the higher teachers, and subjects them to tests in the laboratory which will demonstrate their fitness for teaching science, and when the government will supply us with a well-equipped museum and science library in one building, then but not before we will make satisfactory progress in science.

The thanks of the Institute were presented to Mr. McKay for his services as President.

The Treasurer's report was presented, and having been audited and found correct, was received and adopted. The following is an analytical statement of the expenditure for 1898-99 :—

PUBLICATION OF TRANSACTIONS :—			
Vol. IX, Part 4 (1897-98) :			
Printing and binding	$171 40		
Less received for authors' separates and two copies sold	8 00		
		$163 40	
Vol. IX, Parts 1-4. Preparation of Index		2 00	
Vol. X, Part 1 :			
Printing	$ 8 00		
Photographs for Portrait	1 00		
Engravings	14 13		
Expressage	75		
		23 88	
Vol. X, Part 2, 3 or 4 :			
Photograph for Portrait		25	
			$189 53
DISTRIBUTION OF TRANSACTIONS :—			
Vol. IX, Part 4 :			
Wrappers, receipts, wrapping, twine		$14 50	
Addressing		15 00	
Postage, truckage, freight, expressage, insurance		15 39	
			44 89
Carried forward			$234 42

Brought forward		$234 42
Library Expenses:—		
Insurance (including stock of Transactions)	$16 88	
Janitor, Dalhousie College, for services	5 00	
Asst.-Librarian, Dalhousie College, for services	10 00	
Librarian, clerical expenses	25 00	
Fittings	12 77	
Arranging Library, preparing card catalogue, etc	75 00	
Truckage	3 80	
Binding	95 65	
Freight and postage on back numbers of Transactions sent in exchange	4 01	
Petty expenses	2 55	
		250 66
Calling of meetings		28 00
Advertising		6 00
Postage (Secretaries and Librarian)		11 85
P. O. Box		4 00
Mlscellaneous printing (including stationery)		2 50
Type-writing		50
		$537 93

The Report on the Library was presented by the Librarian and Corresponding Secretary.

During the year the Transactions had been sent for the first time to the following:—

*Königl. Landesarchiv, Agram, Austria-Hungary.
Elektrotechnischer Verein, Berlin, Germany.
Real Academia de Ciencias Naturales y Artes, Barcelona, Spain.
Naturæ Novitates, Berlin.
*Musée du Congo, Brussels.
Baltimore Astronomical Society, Baltimore, Md.
*Maryland Geological Survey, Baltimore, Md.
Library, Harvard University, Cambridge, Mass.
New Hampshire State Library, Concord, N. H.
*Natural History Association of Miramichi, Chatham, N. B.
*K. Vetenskaps- och Vitterhetssamhället, Göteborg, Sweden.
Real Academia de Ciencias Medicas, Fisicas y Naturales; Habana, Cuba.
Periodico di Matematica, Leghorn, Italy.

Lincolnshire Science Society, Lincoln, G. B.
Public Library, Museum and National Gallery, Melbourne.
*Canadian Mining Institute, Montreal.
Club Alpin de Crimée, Odessa, Russia.
Rivista di Patologia Vegetale, Portici, Italy.
Pasadena Academy of Science, Pasadena, Cal.
*Philadelphia Commercial Museum, Philadelphia, Pa.
Rochdale Literary and Scientific Society, Rochdale, G. B.
*Augustana College, Rock Island, Ill.
"Minerva," Strassburg, Germany.
*Institut de Botanique, R. Université des Etudes, Sienne, Italy.
State Laboratory of Natural History, Urbana, Ill.
Concilium Bibliographicum, Zurich-Neumünster, Switzerland.
American Microscopical Journal, Washington, D. C.

Publications have been received for the first time from the institutions indicated by an asterisk in the above list, and from the following:

Observatorio de Manila, Manila.
Education Department, Wellington, New Zealand.
Public Museum, Wanganui, New Zealand.
Birmingham and Midland Institute, Birmingham.
"La Science Sociale," Paris.
Treasury Department, Washington, D. C.
South Staffordshire Institute of Iron and Steel Works Managers, Dudley, G. B.
Radcliffe Observatory, Oxford, G. B.
K. Ungarische Geographische Gesellschaft, Vienna.
Société Anversoise pour la Protection des Animaux, Antwerp.
Society of Civil Engineers, Boston.
Halifax Scientific Society, Halifax, Eng.
Université Imperiale de Moscou, Russia.
Carnegie Museum, Pittsburg, U. S. A.
K. Botanische Gesellschaft, Regensburg.
Kansas State Agricultural College, Manhattan, Ka.
Public Library, New York.
Société Linnéenne de Lyon, Lyons, France.
Academie des Sciences, Belles Lettres et Arts, Lyons, France.
Royal Society of Victoria, Melbourne.
Academy of Science, Washington, D. C.

New England Zoological Club, Cambridge, Mass.
Public Library, Museum and Art Gallery, Adelaide, So. Australia.
Engineering Association of New South Wales, Sydney.
Associazione Mathesis, Leghorn, Italy.
Wisconsin Geological and Natural History Survey, Madison, Wis.
Société Nationale des Antiquaires de France, Paris.
Lloyd Mycological Museum, Cincinnati.

The Transactions were now being sent annually to 779 institutions of various kinds, and exchanges had been received from 447.

The distribution of the Transactions to Corresponding Societies and other institutions in all parts of the world had again, through the courtesy of the Secretary of the Smithsonian Institution, Washington, been effected at small expense, through the Institution's Bureau of International Exchanges. The total expense of distribution had been $44.89, which included printing of wrappers and receipt forms, wrapping and addressing as well as postage (on Canadian packages), and freight.

At the date of the last report 113 volumes were in the binder's hands. Subsequently 89 volumes were added to these; and these 202 volumes are now on the shelves. The total cost of binding them was $170.65, but as $75.00 was provided for last year, only the balance of $95.65 appears in this year's account. The books bound were mostly English, but some foreign publications which were in demand by members were included. The number of bound volumes in the Library is now 1,482; and there must be a somewhat larger number of unbound volumes, though we have never made a count of the unbound volumes.

The recommendation made last year that a paid assistant should be provided to get the library into a condition in which it would be of greater use to the members, was carried out during the past year, the services of Miss N. K. MacKay, who had previously been Asst.-Librarian of Dalhousie College, having been secured for some weeks during the summer.

The following work was accordingly carried out:—

(1) The arranging of books on the shelves and the labelling of shelves referred to in last report, had been completed. It is thus possible for members to find any books they may desire without difficulty, even in the absence of the Librarian.

(2) All unbound volumes, in parts, were examined and tied up, note being made of their defects. This had previously been done in the case

of most of the English books. It has now been done for the whole library.

(3) Memoranda were made out for transmission to corresponding societies, of the parts lacking in our sets of their publications.

(4) A card catalogue of the whole library was prepared according to the method in use in the Library of the Academy of Arts and Science of Philadelphia. The catalogue in the case of serial publications specifies of course only the volumes of the various series which are on the shelves, without giving any clue to their contents. In the case of publications which, though issued by one institution, do not form a numbered series, each volume or report is separately catalogued. The catalogue consists of about 1200 cards.

While the whole of the work, carried out in an admirable manner by Miss MacKay, forms a necessary preliminary to the issue of a printed catalogue for the use of our members, we are not yet ready to issue such a catalogue, at least to issue one which would be permanently useful. For many of the unbound volumes in the library are defective, and it would be well to get these defects supplied as far as may be possible before printing. The Corresponding Secretary hopes during the present year to transmit the memoranda of defects referred to above to the various corresponding institutions, and to make some progress in getting the defects supplied.

The report was adopted, and the thanks of the Institute tendered to Mr. Bowman and Dr. MacGregor for their work in connection with the library.

On motion of Dr. MacKay, it was resolved that the Council be directed to prepare a resolution appreciative of the scientific career of the late Sir William Dawson and regretting his recent death.

It was resolved that the Council be instructed to approach the Government for the purpose of ascertaining if it would be possible for the latter to provide space, in the new Government building, for the accommodation of the Institute's library.

The thanks of the Institute were presented to the Hon. Robert Boak, President of the Legislative Council, for granting the use of the Council Chamber, and to the Secretary of the Smithsonian Institution for his courtesy in continuing to admit the Institute to the privileges of the Bureau of International Exchanges.

The following were elected officers for the ensuing year (1899-1900):

President.—A. H. MacKay, Esq., Ll. D., F. R. S. C., *ex officio* F. R., M. S.

Vice-Presidents.—F. W. W. Doane, Esq., C. E., and Henry S. Poole, Esq., F. G. S.

Treasurer.—William C. Silver, Esq.

Corresponding Secretary.—Prof. J. G. MacGregor, D. Sc.

Recording Secretary.—Harry Piers, Esq.

Librarian.—Maynard Bowman, Esq., B. A.

Councillors without Office.—Alexander McKay, Esq. ; Edwin Gilpin, Jr., Esq., Ll. D., F. R. S. C. ; Martin Murphy, Esq., D. Sc. ; William McKerron, Esq. ; Prof. Ebenezer MacKay, Ph. D.; Watson L. Bishop, Esq. ; Roderick McColl, Esq., C. E.

Auditors.—Herbert E. Gates, Esq., and G. W. T. Irving, Esq.

First Ordinary Meeting.

Legislative Council Chamber, Halifax, 20th November, 1899.

The President, Dr. MacKay, in the chair.

The meeting was held after the adjournment of the Annual Business Meeting.

Dr. H. M. Ami communicated a paper "On the Subdivisions of the Carboniferous System in Eastern Canada," but owing to the lateness of the hour the reading of the paper was deferred.

Second Ordinary Meeting.

Legislative Council Chamber, Halifax, 11th December, 1899.

The President in the chair.

The council reported that Ernest Haycock, Esq., Instructor in Chemistry, Mineralogy and Geology, Acadia College, Wolfville, N. S., had been elected an Associate member.

The following resolution was adopted :—"This Institute has learned with the greatest regret of the death of its distinguished Corresponding Member, Sir J. W. Dawson, and desire to place on record its profound sense of the eminence of the services rendered by him to the cause both of Science and of Education, during a long life, which was happily as fully characterized by successful results, as by unremitting efforts towards the attainment of a noble ideal.

"The Institute desires to convey to LADY DAWSON and her family, an expression of the deep sympathy with which its members have heard of the sad bereavement she and her family have experienced."

A paper by HENRY M. AMI, ESQ., D. SC., of the Geological Survey of Canada, "On the Sub-divisions of the Carboniferous System in Eastern Canada," was read by DR. E. GILPIN who gave an introductory statement of a popular character. (See Transactions, p. 162).

The subject was discussed by DR. GILPIN, MR. J. FORBES and others.

The president, DR. A. H. MACKAY, said he was glad to have DR. AMI's views presented to the Institute. He spent a fortnight with Mr. Fletcher in running over the stream-exposed sections of the southern flanks of the Cobequids; and became deeply interested in some of the problems discussed in the paper. The extremely careful work done of late years had thrown new light on the problems attempted to be solved by the older geologists from their original but more limited observations. Mr. Fletcher has reason to feel gratified that Dr. Ami and Dr. Dawson admit that his maps of the region in question "show clearly the true and natural order of sequence of the formations;" so that the reference to "types that are everywhere held to be of carboniferous age" must indicate a revision of the older geological nomenclature of some regions. Sir William Dawson, a most eminent palæontologist as well as geologist, after studying the fossil plants and animals of Riversdale, MacKay Head, and Harrington River, placed them in the Millstone Grit formation as intimately related to those of the Coal Measures. Dr. Ami now correlates them with the Lancaster fern ledges (hitherto known as Devonian) of New Brunswick; but he would place them all in his new Eo-carboniferous. Of the twenty-one fossil species enumerated by Dr. Ami, fifteen were Dawson's own species. *Psilophyton glabrum* belonged to a genus hitherto generally considered to be characteristic of the Devonian. *Leaia Leidyi* (perhaps identical with *Leaia tricarinata*) was found in rocks called Devonian by many geologists. *Belinurus grandœvus* and *Estheria Dawsoni* represented genera usually considered common both to the Devonian and the Carboniferous, with specific names given to specimens obtained from the rocks in dispute. Dr. Ami's new species *Sauropus Dawsoni* was stated to be only "apparently from rocks of this age." Mr. Fletcher would appear to oppose the assumption that the rocks underlying the New Glasgow conglomerate

are equivalent to the coal measures of Stellarton, according to his views given in the Report of the Geological Survey for 1886, which he did not appear to have since changed.

These differences of opinion demonstrated that new information was being acquired, and was in the course of being assimilated by the geologists. But whether taking the upper slice from off our old slenderly developed Devonian and attaching it with its unconformity to the base of our corpulent Carboniferous is the true rectification of the old nomenclature, remained, perhaps yet to be indubitably determined. If the true order of superposition of rocks can be ascertained at any point from the observation of their actual bedding, the palæontologist must modify his hypotheses based on defective biological horizons observed elsewhere, so as to harmonize with the facts of the stratigraphist. It was the stratigraphist in the first place who determined the biological horizons for the palæontologist. But the palæontologist with his biological horizon becomes the supreme arbitrator where the stratigraphist is not sure of his base, or of the order of superposition.

Prof. J. G. MacGregor, communicated a paper, "On Laws of Dilution for Aqueous Solutions of Electrolytes."

Third Ordinary Meeting.

Legislative Council Chamber, Halifax 15th January, 1900.

The President in the chair.

A communication was read from the Eighth International Congress of Navigation, inviting the Institute to appoint a delegate to attend the meeting of the Congress to be held at Paris in July next. The matter was referred to the Council for action.

James Barnes, Esq, B. A., Dalhousie College, presented two papers :—

1. "On the Relation of the Viscosity of Mixtures of Solutions of Certain Salts to their State of Ionization." (See Transactions, p. 113).

2. "On the Calculation of the Conductivity of Aqueous Solutions containing Hydrochloric and Sulphuric Acids." (See Transactions, p. 129.)

A vote of thanks was presented to Mr. Barnes for his communications.

Fourth Ordinary Meeting.

City Council Chamber, Halifax, 12th February, 1900.

The President in the chair.

A paper entitled : "Nova Scotian Minerals collected for the Paris Exhibition," was presented by Edwin Gilpin, Jr., Esq., Ll. D., F. R. S. C., Inspector of Mines. Dr. Gilpin answered a number of inquiries made by those present, relative to the minerals of the Province. (See Transactions, p. 248.)

A communication by Henry S. Poole, Esq., F. G. S., entitled "Notes on the Periodical Appearance of Ants in a Chimney, and on an Unusual Site for a Humble-Bee's Nest," was read by the Recording Secretary in the absence of the author, as follows :

"For many years, possibly fifteen, a flight of ants has annually tumbled down a chimney in the office of the Acadia Coal Co., at Stellarton, N. S., generally on August 24th, sometimes a day or two later, and occasionally a few ants again appear as late as the middle of September. Fires are used in the chimney each winter. A tinned roof has been put on the office since the ants first were seen, and the top of the chimney has been thoroughly repaired by masons without finding a nest. The habitat selected seems unusual, and so far has not led to the similar adoption by colonies of other chimneys in the same building.

"In a grove of young fir trees, about eight feet from the ground, I noticed one autumn a large robin's nest in unusually good repair. On pulling down the tree-top the nest was found to be full, with a dome shaped cone. It was occupied by humble-bees and a small comb with larvæ in it. Such a situation for a humble-bees' nest, I am told, has been seen before, but apparently it is unusual."

Fifth Ordinary Meeting.

City Council Chamber, Halifax, 12th March, 1900.

The President in the chair.

It was announced that Charles Pickford, Esq., had been elected a Corresponding Member.

A paper by C. M. Pasea, Esq., of Dalhousie College, "On a relation between the Ionization Coefficients of Electrolytes, and its application as an Interpolation Formula," was presented by Dr. J. G. MacGregor.

James Barnes, Esq., B. A., Dalhousie College, read a paper "On the Depression of the Freezing-point by Mixtures of Electrolytes." (See Transactions, p. 139.)

The paper was discussed by Drs. MacGregor and MacKay, and a vote of thanks was presented to the author.

Dr. A. H. MacKay, exhibited, with comments, material taken from the bottom of the Atlantic at four different points, by the Cable S. S. *Minia* in charge of Captain De Carteret, by whom the specimens were presented.

1. From lat. 40° 47' N., long. 38° 45' W., at a depth of 2544 fathoms, in June, 1899 :—

a. A fragment of a dark igneous rock about 13x8x5^{cm}, not very unlike some massive, dark green traps of Nova Scotia. The Cable was hooked at the same time, but broke and slipped over the stone which was abraded in two separate places. The exact determination of the rock, as well as the other specimens, had to be postponed to a future opportunity after which the results of their special examinations would be communicated.

b. A fragment of gneiss or granite with dark, fine-grained mica, about a centimeter cube, in

c. Mud, which on an average of three samples gave 72 per cent insoluble in nitric acid, leaving 28 per cent for carbonate of lime in foraminiferal shells, and any other soluble matter which might be present. The species of foraminifera present were left for future enumeration. The mud was, therefore, about three-quarters derived from decomposed rock, and contained specks of mica flakes among the minute sand grains also found in it.

2. From lat. 49° 30' N., lon. 49° 36' W., at a depth of 2594 fathoms, were taken on the 3rd July, 1894:—

a. A fragment of rock about 8x4x3^{cm}. It was a very compact, fine-grained, dark (with a band of light grey) chocolate quartzose felsite in appearance, breaking with a conchoidal fracture, a portion of one side looking as even as if it were ground plane. The light grey band on the opposite side suggested discoloration by weathering, and the conchoidal fracture in this portion was much rougher in its surface texture.

b. A fragment of a water-worn, whitish, cryptocrystalline quartzite pebble about 3^{cm} in its three dimensions.

c. Mud with small pebbles, containing what suggested the remains of a cœlenterate animal with slender stem, cylindrical body a few

centimeters long, with slender tentacular processes. This material was originally bottled in alcohol which had nearly all evaporated before examination, and the organism was not intact. The mud contained siliceous grains with occasional sponge spicules, &c.

3. From a depth of 30 fathoms, about 15 miles E. N. E. (magnetic) from Flat Point, Sydney, C. B.

a. Thin brachiopod shells, the largest about $28x22^{mm}$.

b. What suggested arborescent Polyzoan Zœcia, about 1^{dm} high, the cylindrical spray of branches having a diameter of about 15^{mm}.

c. A sheet of the eggs of a gastropod.

4. From between

lat. 43° 52′ N., lon. 58° 53′ W. in 500 fathoms,
lat. 43° 53½′ N., lon. 58° 59½′ W. in 858 fathoms,
and lat. 43° 56′ N., lon. 59° 3′ W. in 170 fathoms.

A coral, of the form of *caryophilia*, rising from a thin encrustation partly surrounding a pitch-covered cylinder (Cable) about 3^{cm} in diameter, with a stem about 1^{cm} at the base, gradually expanding until at a height of 4^{cm} it formed an elliptical cup-shaped corallite about 3.5^{cm} and 4.5^{cm} in diameter, filled with numerous septae of unequal height, in one series.

SIXTH ORDINARY MEETING.

Legislative Council Chamber, Halifax, 9th April, 1900.

The PRESIDENT in the chair.

The RECORDING SECRETARY read a communication from the Royal Society of Canada, inviting the Institute to appoint a delegate to attend the nineteenth general meeting of the Society to be held at Ottawa on the 29th of May next. The communication was referred to the Council for action.

PROF. ERNEST HAYCOCK of Acadia College, Wolfville, N. S., read a paper entitled : "Records of Post-Triassic Changes in Kings County, N. S." (See Transactions, p. 287.)

The subject was discussed by DR. GILPIN and MR. MCKAY, and a vote of thanks was presented to the author.

The PRESIDENT, A. H. MACKAY, ESQ., LL. D., read a paper on "A Fresh-Water Sponge from Sable Island." To this species Dr. MacKay proposed to give the name *Heteromeyenia Macouni.* The subject was illustrated by microscopic preparations. (See Transactions, p. 319).

Seventh Ordinary Meeting.

Legislative Council Chamber. Halifax, 14th May, 1900.

The President in the chair.

It was announced that the President, Dr. MacKay, had been appointed delegate to represent the Institute at the forthcoming meeting of the Royal Society of Canada.

It was reported that progress had been made in fitting up a room for the library of the Institute, etc., in the new government building, Hollis Street.

In the absence of the author, Dr. MacGregor read a paper by Prof. John Davidson, of the University of New Brunswick, Fredericton, on "The Natural History of Money." (See Transactions, p. 179.)

The paper was discussed by Colonel McShane, Dr. H. H. Read, Frererick P. Ronnan, Esq., and others, and a vote of thanks was presented to Prof. Davidson for his communication.

A. H. MacKay, Esq., LL. D., F. R. S. C, read a paper entitled "Phenological Observations, Canada, 1899. (See Transactions, p. 303.)

A paper by T. C. Hebb, Esq., B. A., Dalhousie College, "On the Variation of the Rigidity of Vulcanized India Rubber with Tension," was presented by Dr. MacGregor. (See Transactions, p. 273)

The following papers were read by title :—"Notes on a Cape Breton Mineral containing Tungsten, and on the effect of washing certain Cape Breton Coals,"—By Henry S. Poole, Esq., F. G. S., Stellarton, N. S. (See Transactions, p. 248.)

"Geological Nomenclature in Nova Scotia,"—By Hugh Fletcher, Esq , Geological Survey of Canada. (See Transactions, p. 235.)

A collection of dried plants from the vicinity of Buffalo, U. S. A., made by Rev. Brother Junian Peter, St. Joseph's Commercial College, Detroit, and presented by him to the Institute, was shewn, and a vote of thanks was passed to Brother Peter for his gift.

The council was authorized to receive as having been read by title, any papers that might be offered too late for this meeting. [Under this resolution a paper subsequently submitted by Prof. J G. MacGregor, "On a diagram of Freezing-point Depressions for Electrolytes," was accepted by the Council. (See Transactions, p. 211).]

HARRY PIERS,
Recording Secretary.

John Matthew Jones

PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1900-1901.

Annual Business Meeting.

Legislative Council Chamber, Halifax, 19th November, 1900.

The President, Dr. A. H. MacKay, in the chair.

The President addressed the Institute as follows:—

Gentlemen,—It has been customary at our Annual Meetings for the retiring President to make a summary review of the year's work—a sort of annual inventory. In following this custom, were I speaking to the general public, I would be required to give some kind of demonstration of the object and value of such work as we are doing in line with similar organizations in every civilized country. For those who see a fine mushroom grow in one night are generally unaware of the one hundred nights and the one hundred days during which its invisible white, silken, threadlike mycelial cells were tunnelling the surrounding earth in myriad lines with ceaseless activity, so that when the appropriate time should come tens of thousands of microscopic tubular lines of transport should simultaneously carry from every quarter the duly assimilated matter to build up and complete in a few hours the visible and generally appreciated fruit. Every great discovery or invention of modern times popularly considered great, is in like manner simply the fruit of the unostentatious, patient and continuous labor of a multitude of seekers after knowledge of the truth, the whole truth, and nothing but the truth, in one or more regions of the infinite domain in which we exist. Without these humble and severely accurate observations of fact and measurements of force going on from year to year there can be no

longer expected at smaller or greater intervals in the future those brilliant generalizations which dazzle the multitude and form an epoch in the history of man.

We may perhaps have met with some indications that there are people who think that an Institute of Science such as ours should devote itself to the grand problems of human life in such a manner as to electrify the public, convince the sceptic, and reform human society on lines based on indubitable principles. Such persons seem to expect that if scientific men are of any use they could by the application of their thinking powers discover these grand principles and demonstrate them with the potency of universal conviction. They are evidently unaware of the most striking fact in the history of man, that from the beginning of society up to their own appearance in the role of thinkers, men have been trying to solve these problems by thinking, striving to draw knowledge out of brains into which the knowledge never entered. The deductive metaphysical philosophers of old are still being produced, more numerous than ever if not more powerful, and the ancient problems are not yet solved.

We have never yet gained any advantage by thinking out what nature should be. We have to find out what it is, and so far as we know what it is we can utilize it according to our limitations. And the solutions of the so-called grand problems are often dependent on what might be called the humblest facts. The grandness of a truth discovered cannot be known until the full train of its effects can be seen; so that to the truth seeker any truth may well be considered grand. It is a sound principle for each to seek whatever truth is nearest him, so that he may add it to the common stock which is now becoming the broad base of the so-called grand truths which humanity has learned to applaud after a period of suspicion.

This is the principle on which our Institute is working. The geologist is near to the discovery of new geological facts by reason of his previously obtained geological knowledge and his opportunities of studying for years his own local ground. He exercises his special powers with the result of obtaining further knowledge which through our publications are made the property of the truth-seekers throughout the world. And so with each of us. We have our own special opportunities for some kind of exact observations on points not hitherto exactly observed, and in making such observations we are as deserving as he who makes the final

observation to complete a grand theory, providing we have brought the same energy and ingenuity to bear on our problems.

The discovery of grand principles—of great truths—is now more than ever before a composite work contributed to by many knowledge makers. The South American Indian who first by accident discovered the anti-malarial effect of the extract of Peruvian Bark, discovered a great fact without any special preparation and possibly without the aid of any previous more or less partial observer. But still, for over three centuries the *Hæmamœba vivax* and *Hæmamœba malariæ*, living jelly specks so infinite that a blood corpuscle is a meadow for them, got through the human skin (more than a Chinese wall for them), and into the blood stream, and from thence into the blood discs themselves, which they finally destroyed.

It was not until twenty years ago that Laveran discovered their presence in the life fluid, but how impossible would it have been for him to have discovered such organisms until the microscope had been improved to a high degree of excellence and microscopic methods had been discovered by other workers. Yet no one could show how the minutely microscopic animal more destructive to the human race than all the historical beasts of prey, found its way into the blood. Multitudes of observers finally seemed to relegate the home of the organism to the malarial swamps, but it could not be found in the swamps. These observers, however, made a very important contribution to the general stock of knowledge, for as the mosquitoes pass their larval stage in water, suspicion was finally extended to them. Yet people were taking great care to protect themselves from the malarial air which poisoned no one, while infected mosquitoes were allowed to inoculate them unsuspectingly on the adjacent dry lands. Danilewsky, Golgi, Antolisei, Grassi, Bignami, Bastianelli, Labbe, Mannaberg, Manson, Nuttall, Metchnikoff, Daniels, McCallum, and others, and finally Ronald Ross, worked on the humble mosquito until 1899 before the problem was solved.

Other specimens of *Hæmamœba* were found in the common mosquito and in other animals who were inoculated by the mosquito, and who in turn could infect sound mosquitos. Finally species of a genus of mosquitos, *Anopheles*, were found infected with the malaria *Hæmamœba* in a most unexpected form. Sound *Anopheles* were found to be infected by feeding upon the malarial patient, and infected ones communicated malarial fever to those whom they were allowed to bite. For about

twenty years these men from every country of Europe were studying the life and particular habits of the mosquitos, each contributing something to help the others. But should it be asked what species of the mosquito we have in Nova Scotia, all we could say is that thirty different species are generally recognized on the continent. But we could not say how many are to be found here. We only presume that *Culex pipiens* is the common if not the only one.

If we had some observer studying the humble subject of our mosquitos, even were in only demonstrating the different species to be found in this Province, we should have some share in this important discovery of the close of the century. In the meantime our high flown deductive philosopher racking his brain in circling after grand truths, is circling still, as near and yet as far as ever from the mental mirage he is following. The grand truths oftentimes come from the most unexpected directions; therefore it is wise for us to hold all truth in esteem and worth the seeking.

The past year is also, to a marked extent, the beginning of a new epoch in the history of our Institute. The Provincial Museum, although not the property of the Institute, was built up by the members of the Institute, and was from the beginning its headquarters. But for the last few years it had become so crowded by the accumulation of material and the lack of a curator, such as it had during the lifetime of Dr. Honeyman, that it served neither as an efficient museum nor as a desirable meeting place. Besides, our rapidly accumulating library, coming mainly as exchanges from the leading scientific institutions and societies all over the world, could not at all be accommodated. For the last few years the Council had to procure temporary accommodation for it in the University building of Dalhousie, where there was proper library room for but a portion of its volumes.

The Provincial Government having seen the great importance of stimulating scientific study as the foundation of a safe and rapid industrial development of the country, and having the good fortune to be able to secure on good terms the fine building adjacent to the Province Building as an annex, with spare room beyond the immediate demands for offices, determined to provide the ways and means for the public utilization of all this hidden wealth. The Museum has been transferred to the new building and re-arranged on scientific lines under the curatorship of Mr. Harry Piers, who is rapidly making it a real Provincial Museum.

Students will already find it well classified, so as to show the products of the country of scientific and economic interest to their best advantage. The numerous blanks are being filled as rapidly as specimens can be secured, and each object is in the process of being labelled so as to give not only its name but a summary of such information respecting it as is most likely to be of use.

On the adjacent flat the Government has provided ample library accommodation for the Library of the Institute and the books from the Legislative Library bearing on science and the arts, with a reading room. There is also sufficient accommodation for the Library of the Mining Society of the Province. In this manner all these scientific collections increasing from day to day, all these libraries also increasing from day to day, are made available freely to students, miners, manufacturers, and the public generally.

Under the capable management of Mr. Piers, these institutions are not only sure to give satisfaction to the Government, but to the public, who are thus admitted to invaluable privileges which previously even members of the Institute could not avail themselves of without much loss of time and inconvenience to others. The Government, in assuming the charge of this composite Library, are able to open to the public the invaluable, modern, and rapidly growing library of the Institute; and the members of the Institute, on the other hand, have also gained thereby easy access to their own literature. This co-operation of interests is of mutual benefit, and the Science Library and the Museum are likely to become an important centre for the scientific students of the city and the Province. The Museum is already open, and in a short time the Library will be in working condition.

There are also signs that the scientific side of educational work throughout the Province is improving, notwithstanding the defects common to our schools and colleges throughout the continent. May the time be not far distant when our Institute may have more recruits to undertake the infinite range of work before us—in discovering the yet hidden truths of nature lying around us on every hand within our own Province, without a knowledge of which we cannot expect to solve indubitably what people call the great problems of the world.

The President referred with regret to the loss of two invaluable associate members, Captain Trott, of the Cable S. S. "Minia," and Rev. Arthur C. Waghorne, who had done so much in the botanical exploration of Newfoundland.

A vote of thanks was presented to the PRESIDENT for his address, and for his services during his term of office.

The TREASURER's report was presented, and having been audited and found correct, was received and adopted.

The thanks of the Society were presented to MR. SILVER for his services as TREASURER.

In the absence of the LIBRARIAN, the report on the Library was read by DR. MACGREGOR. The report was received and adopted.

In recognition of the services of MR. BOWMAN as librarian for several years, it was resolved that he be elected a life-member.

The thanks of the Institute were presented to the HON. ROBERT BOAK, President of the Legislative Council, for granting the use of the Council Chamber; to HIS WORSHIP THE MAYOR, for the use of the City Council Chamber; to the BOARD OF GOVERNORS OF DALHOUSIE COLLEGE, for the use of a room in the College building for the purpose of accommodating the society's Library; and to the SECRETARY OF THE SMITHSONIAN INSTITUTION, Washington, for continuing to admit the Institute to the privileges of the Bureau of International Exchanges.

The following were elected officers for the ensuing year (1900-1901):—

President.—A. H. MACKAY, ESQ., LL. D., F. R. S. C., *ex officio* F. R. M. S.
Vice-Presidents.—F. W. W. DOANE, ESQ., C. E.; and HENRY S. POOLE, ESQ., F. G. S., F. R. S. C.
Treasurer.—WILLIAM C. SILVER, ESQ.
Corresponding Secretary.—PROF. J. G. MACGREGOR, D. SC., F. R. S.
Recording Secretary.—HARRY PIERS, ESQ.
Librarian.—MAYNARD BOWMAN, ESQ., B. A.
Councillors without office.—ALEXANDER MCKAY, ESQ.; EDWIN GILPIN, JR., ESQ., LL. D., F. R. S. C.; MARTIN MURPHY, ESQ., D. SC; PROF. EBEN MACKAY, PH. D.; WATSON L. BISHOP, ESQ.; RODERICK MCCOLL, ESQ., C. E.; H. W. JOHNSTON, ESQ., C. E.
Auditors.—WILLIAM MCKERRON, ESQ., and G. W. T. IRVING, ESQ.

FIRST ORDINARY MEETING.

Legislative Council Chamber, Halifax, 19th November, 1900.

The PRESIDENT, DR. MACKAY, in the chair.

The meeting was held after the adjournment of the Annual Business Meeting.

It was announced that J. R. DeWolfe, Esq., M. D., Halifax, and Walter H. Prest, Esq, M. E, Bedford, N. S., had been elected corresponding members.

Owing to the lateness of the hour, the reading of Mr. Fletcher's paper "On Geological Nomenclature of Nova Scotia: New Glasgow Conglomerate," was deferred.

Second Ordinary Meeting.

Legislative Council Chamber, Halifax, 10th December, 1900.

The President in the chair.

It was announced that Miss A. Louise Jaggar, Smith Cove, Digby Co., N S., had been elected an associate, and Charles Henry Davis, Esq., C. E., New York, U. S. A, an ordinary member.

The President read a paper by Hugh Fletcher, Esq., of the Geological Survey of Canada, entitled, "Geological Nomenclature of Nova Scotia: New Glasgow Conglomerate." (See Transactions, p. 323.)

The paper was illustrated by a large geological map, by Mr. Poole, of the locality described.

Third Ordinary Meeting.

City Council Chamber, Halifax, 14th January, 1901.

The President in the chair.

Henry S. Poole, Esq., F. R. S. C., presented "A Description of the Davis Calyx Drill."

The subject was discussed by Messrs. Bishop and Anderson, and Drs. Murphy and MacKay.

Dr. MacKay read a paper by Walter H. Prest, Esq., M. E., "On Drift Ice as an Eroding and Transporting Agent." (See Transactions, p. 333.)

The paper was discussed by Drs. MacKay and Murphy, Prof. H. W. Smith, and Messrs. Poole and Piers.

FOURTH ORDINARY MEETING.

City Council Chamber, Halifax, 18th February, 1901.

The PRESIDENT in the chair.

It was announced that PROF. EVERETT W. SAWYER, of Acadia College, Wolfville, and PROF. F. C. SEARS, Director of the N. S. School of Horticulture, Wolfville, had been elected associate-members.

A communication was read by the RECORDING SECRETARY, from the ENTOMOLOGICAL SOCIETY OF BELGIUM, announcing the death of its Honorary President, the BARON DE SELYS-LONGCHAMPS.

On motion it was resolved that the N. S. Institute of Science express its deep sympathy with the Entomological Society of Belgium in connection with the irreparable loss which the society has sustained through the death of its Honorary President, the Baron de Selys-Longchamps.

A communication was also read from the ZOOLOGICAL-BOTANICAL SOCIETY OF VIENNA announcing the celebration of its fiftieth anniversary.

On motion it was resolved that the N. S. Institute of Science offer its cordial congratulations to the Zoological-Botanical Society of Vienna, on the celebration of its fiftieth anniversary and the completion of fifty years of fruitful work, and express the hope that the society's efforts for the advancement of science may, in the future, as in the past, be crowned with success.

PROF. H. W. SMITH, B. Sc., of the Provincial Agricultural School, read two papers, entitled, (1) "Rotation of Leguminous Crops," and (2) "The Preservation and Use of the Tops of Turnips and other Root Crops."

The subjects were discussed by HON. T. R. BLACK, DR. MACKAY, MR. G. MARSHALL, and others.

A vote of thanks was presented to PROF. SMITH for his communications.

Owing to the lateness of the hour, the reading of MR. POOLE's paper on "Stigmaria Structure," and of DR. MACKAY's "Note on Gravel taken by the mushroom-anchor of the 'Mackay-Bennett,'" were postponed.

FIFTH ORDINARY MEETING.

City Council Chamber, Halifax, 18th March, 1901.

The PRESIDENT in the chair.

It was announced that GEORGE M. EDWARDS, ESQ., B. SC., Halifax, had been elected an ordinary member.

A communication was read from the ROYAL SOCIETY OF CANADA, asking the Institute to appoint a delegate to attend the Society's meeting to be held at Ottawa on May 21st. The matter was referred to the Council.

On motion, the Council was directed to prepare a resolution expressive of regret at the death of the late DR. J. R. DEWOLFE, one of the Institute's oldest members.

[The resolution, subsequently prepared, was as follows :—

"*Resolved*, That the Council place on record its deep sense of the loss sustained by the Institute through the death of Dr. DeWolfe, who was well known in his profession, was elected a member of the Institute on 26th October, 1863, was for a number of years a member of the Council and also second Vice-President, always took a deep interest in and actively furthered the aims of the society, and was at the date of his death the oldest living member.

Further resolved, That the Secretary be directed to send a copy of the resolution to the family of the deceased, and to express to them the sympathy of the Institute in their bereavement."]

HENRY S. POOLE, ESQ., F. R. S. C., read a paper "On a Polished Section of Stigmaria showing an axial cellular structure." (See Transactions, p. 345.)

A. H. MACKAY, ESQ., LL. D., presented the results of a microscopic examination of the specimen of Stigmaria. (See Transactions, p. 346.)

The subject was discussed by MESSRS. BISHOP and A. MCKAY.

A. H. MACKAY, Esq., LL. D., read a "Note on Gravel taken by the mushroom-anchor of the 'Mackay-Bennett,' cable steamer, from the bottom of the Atlantic, 40 miles west of Sable Island."

The paper was discussed by MR. POOLE.

WATSON L. BISHOP, ESQ., read a paper on "The Star-nosed Mole," and exhibited specimens of the young. (See Transactions, p. 348.)

PROF. J. G. MACGREGOR, D. Sc., communicated a paper "On the use of the Wheatstone Bridge with Alternating Currents."

SIXTH ORDINARY MEETING.

City Council Chamber, Halifax, 5th April, 1901.

The PRESIDENT in the chair.

A communication was read from the ENGINEERS' SOCIETY OF WESTERN NEW YORK, Buffalo, offering the use of the society's rooms to any member of the Institute who may visit the Pan-American Exposition. The SECRETARY was directed to make a suitable reply.

The following paper was communicated :—

THE RARE EARTHS: THEIR SCIENTIFIC IMPORTANCE AS REGARDS THE PERIODIC LAW.—BY W. H. MAGEE, PH. D, *High School, Parrsboro, N. S.*

AT a meeting of scientists, it is, of course, unnecessary for me to apologize for the fact that the subject of my paper is one in which the general public takes no interest. There are few, even among chemists, who take more than a passing interest in the so-called Rare Earths. You, however, who are seekers after truth, are aware that even in what might seem the most despicable of materials there are startling discoveries awaiting the patient investigator who will delve into the hidden mysteries and bring to light truth, not only of rare interest to the scientific circle whose sympathies he enjoys, but of advantage to the general public which, though impatient of the labor and details, is ever ready to avail itself of, and to liberally reward, results.

The term Rare Earths, is, if not a misnomer, at least misleading, since there are earths or oxides not classed in the group which are as rare, if not rarer, than these themselves. The usually accepted definition of a rare earth is "a substance precipitable by oxalic acid from a weakly acid solution and having the formula $R_2 O_3$ in which R stands for the element of the oxide." This definition, however, if rigidly adhered to, excludes Ce., Th. and Zr., which are usually ranked with the rare earths and, being applied ever so generally, would place Tl., Ga., Ge., In., etc., among the ordinary or at least not rare earths.

The full list of these earth elements includes Ce., Zr., Th., La., Sc., Yt. and Yb., which are looked upon by chemists as actually elemental, and Pd., Nd., Sm., Ho., Er., Ter., Th., De., Dp., Ph., and even others which appear to differ from each other as oxides and may, some of them at least, be elemental, but are probably in most cases mixtures of two or more elements. They are not, however, known in the elemental condition but only in the form of oxides and salts. Some few have been reduced to the metallic condition yielding then grayish-white metals, but in such small quantities, and with such doubts regarding their purity, that slight advantages have been derived from the reduction.

Before considering the properties of these substances and discussing their importance in the periodic system, it will be well to look into their history. They were first brought to the knowledge of the chemical world during that period of remarkable activity at the close of the 18th and beginning of the 19th centuries. Probably the first time that any mineral containing these oxides in any considerable quantity was noticed was in 1751, when Cronstedt obtained from an iron mine in Sweden a sample of the mineral now known to mineralogists as Cerite, a silicate of Ce., La. and Di., containing as impurities or accessories, however one chooses to consider them, small quantities of other rare oxides, together with iron, alumina, lime and traces of Mn., and even other minerals. This mineral was first analysed by D'Elhuyar in the laboratory of the noted chemist Bergmann, and stated to be a silicate of Fe. and Ca. It may seem remarkable that, even in those early days of chemistry—this was in 1784—such an error as the mistaking of the trivalent oxides for the very common substance lime should occur, but if the experience of such a noted analytic chemist as Plattner, so late as 1846, be considered, all wonder ceases. This chemist analysed several times the mineral Pollux from Elba and, despite all his care, and he was renowned as an analyst, he could only get his results to foot up to 92.75 per cent., nor could any one explain the matter until Bunsen recognized a new metal, Caesium, in the water of the Durkheim salt wells and proved it to be of the alkali group thus closely resembling Na. and K. Plattner had been reckoning Cs. with an atomic weight of 132 as K. with an atomic weight of 39, and neither he nor his contemporaries seemed capable of proposing the very simple explanation that there must be present a new element. This experience of Plattner's and its explanation probably saved Winkler from a similar error in 1886 and gave him the credit of the discovery of a new element. Repeatedly analysing Argryodite, as

he was chemist of a silver mining company in the Freiburg district in Germany, he met with a constant loss of 7 per cent. in his analyses, and a close search with refined methods enabled him to announce to the world the new metal Germanium.

But I have digressed. The matter rested after D'Elhuyar's time until the fame of the two great analysts, Berzelius and Klaproth, induced some one to send to each of them a sample of the mineral. These chemists soon decided that lime was not the main constituent and that though iron was present it was only in mere traces. Both set themselves to solving the problem and almost simultaneously announced to the world the existence of a hitherto unknown element. There was considerable discussion as to which could claim the precedence, but the scientific world has yielded the palm to Berzelius by adopting his name, Cerium, instead of ochroit-erde proposed by Klaproth. In tracing out the history of this interesting mineral however, we have really passed the date when the apple of discord was thrown among the chemical family. The date of the discovery of an oxide containing the unknown element Ce. was 1804, the date of the discovery of the first of the rare earths was 1789 when Klaproth isolated Zirconia. If this be disputed, for Zr. does not fulfil all the conditions of a rare earth, we must yet anticipate 1804, for in 1794 Gadolin, a Finnish chemist, gave to the world Yttria, the oxide of Yttrium which fulfils in every respect the conditions of our definition. This element was discovered in a mineral from Ytterby, in Sweden, which mineral has since been named in honor of this chemist Gadolinite.

In 1818 Berzelius announced the discovery of a new oxide, Thoria, in some rare minerals from the neighbourhood of Fahlun, Sweden. This discovery he confirmed in 1828 when he found the same oxide in a mineral from Brewig, in Norway. Before going into the history of the very remarkable period which followed, let us see just what was known up to 1835. Ceria, Zirconia, Thoria and Yttria were recognized as distinct oxides, each supposed to contain a distinct element. Only one of these, however, Yttria, belongs to the rare earths, if we keep to the strict letter of our definition. Such, then, was the knowledge of the rare earths; they were ordinary oxides of no more interest than lime or baryta, nay, not so much, for they were of no practical use, they were *rare*, and so of no interest except to seekers after curios.

In 1837-38 a young Swedish chemist, a pupil of Berzelius, took up the neglected earths and under his magic touch, for he was a genius, new

truths were rapidly unfolded and a new interest was given to this portion of the chemical field, an interest which has constantly increased, and under the influence of which research will go on until these most subtle elements yield to the scientists truths even more deeply and cunningly concealed than those which are being discovered in the realms of electricity and bacteriology. I think it is no exaggeration to say that nothing would give more pleasure to the chemical world than to find a solution to the mystery which surrounds these rare earths, now rare no longer, if by the word, we mean scarce, but truly rare if we consider it as meaning costly or worthy as regards the chemical truth concealed among them. This chemist was Mosander—a name probably unknown outside the chemical world, and not to all chemists. To the advanced inorganic chemist, however, he is the pioneer in the field, since he was the first to show the immense possibilities which lay concealed in the little then known of these peculiar earths.

Beginning an examination of Ceria he soon announced that it was not a simple oxide but a compound of at least two. This was in 1838. In 1843 he announced that one of these two could be still further decomposed and so from the earth Ceria, long considered a simple earth, there resulted a pale yellow oxide, ceria proper, a brownish white oxide, lanthanum, and a dark brown oxide, didymia, the first yielding yellow, white, and red salts, the second white or colorless, and the third pink salts. As a result of this discovery, an immediate attack was made on the other rare earths. Mosander himself in the following year announced Erbia and, later, Terbia, as earths separable from Yttria; these yield, Yttria colorless salts, Erbia yellow, and Terbia rose colored, a coincidence with the compounds from the Ceria earths. In 1860 Berlin, as a result of long research, announced that Mosander had been mistaken as regards Yttria, but later work has shown that the Swedish chemist had not spoken heedlessly, for Bahr and Bunsen, by a very brilliant piece of work, proved the presence of Erbia in so-called Yttria, and in 1873 Cleve and Hoglund confirmed this. About this time Delafontaine again determined the existence of Terbia. Later, Delafontaine claimed the discovery of an earth, which he called Phillipia, in the Yttria, but this is not as yet acknowledged by chemists. Then came a classical research by Marignac, a Swiss chemist, in which, after separating out several apparently distinct earths, he finally isolated Ytterbium, which is undoubtedly a distinct element, though some chemists, keeping in view the many surprises in this field, still withheld acknowledgment. In 1879, Nilson,

another remarkable Swedish chemist, isolated Scandium, and since that time Cleve claims to have found in Erbia a threefold group for one member of which he retains the name Erbia, calling the others Thulia and Holmia.

In the meantime, from a sample of Didymium obtained from the mineral Samarskite, first found in North Carolina, a new oxide, Samaria, was separated in 1878 by Boisbaudran and Delafontaine, acting separately, the latter calling it Decipium. Finally, in 1883, Didymium, which since 1842 had held its place as an element, and from which a metal had been isolated and which had played a prominent part in several quite bitter chemical discussions, all parties basing their arguments on its being an element, was, by Welsbach, a chemist of Vienna, best known as the inventor of the Auer or Welsbach Light, disintregated into what, for want of better name, are called, (or perhaps I should say into tentative substances,) Praseodidymium and Neodidymium. Still more recently, Bettendorf has obtained evidence of the presence of still another oxide in Yttria, which he proposes to name in honor of the original discover of Yttria, Gadolinum.

It has been twice thought that Zirconia was not elemental, once in 1845, when Svanberg thought he had isolated Noria, and again in 1866-7, when Sorby thought he had found Jargonia. Both were subsequently proven to be Zirconia, or it was shown, at least, that there was not enough evidence to consider them elemental earths.

You will note then, that from the two original earths, the Yttria of 1789 and the Ceria of 1804, not less than eleven earths have been isolated and probably two or three more, though the evidence is less conclusive. When I mention that the knowledge of these, though very accurate, is less than that known of our ordinary elements at, say 100 years ago, it will be seen that a wide field exists here for investigators.

Why is so little known concerning them? The answer might be hazarded that it is because of their rarity. This is not so, however, as several of them have been proved to exist in considerable quantities. The trouble lies in their close resemblance to one another, chemical reagents acting similarly toward them all, and thus the only means of separating them is by taking advantage of the difference in basicity of their compounds. This is a very slow process and uncertain, for, being fractional, it is only made exact by numberless repetitions, and so it is extremely difficult to get pure material on which to experiment. This

same trouble, too, is one of the chief reasons for the appearance on several occasions of pseudo elements which, obtained with extreme difficulty, seemed to have a fair claim to separate existence, and which required considerable time and skill to prove their non-existence.

Let me illustrate. You are all aware that in the case of our ordinary elements there are sharp points of separation. HCl. throws down from a silver salt solution all (or nearly all, for this reservation must be made in the light of refined methods) the silver as AgCl. H_2S throws down from solution a large number of sulphides even in acid solution we must grant, but for every one of these elements there is some known reagent or some exact method of treatment, which affects one and only one of these elements. There are, undoubtedly, difficulties in exact separations, but a fair analytical chemist can always separate them. With the rare earths, however, each reagent seems to act so similarly that there is no sharp line of demarcation, and the only methods applicable to their separation are slow and remarkably difficult of application. Absolutely quantitative analytical processes are unknown, and no results published in the various mineralogical books as giving the composition of the minerals containing them are reliable. I put forward no claims to superiority as an analytical chemist, but I was occupied from October 1st to the Christmas vacation, with all the advantages of a well equipped laboratory at my disposal, in obtaining 11 grams of pure Ceria, using a method proclaimed as the best to date, but acknowledged to need, as my experience also confirms, a seven times repetition to ensure so-called purity, and leaving behind the suspicion that, as it was purified according to the standard of a vanishing test, it was even then not absolutely pure. Yet this subject has received some of the best thought of the ablest chemists of the world during the past 50 years. Bahr, Bunsen, Rammelsburg, Wolf, Wing, Gibbs, Wöhler, Popp, Crookes, Marignac, Delafontaine, Boisbaudran, Nilson, Cleve, Kruss, Bettendorf, Welsbach, in fact all the advanced inorganic chemists of the past half century. There is no discouragement, the fight goes on with that grim determination to succeed which only the scientist knows. What have they accomplished for the world? Not much in this line! But if these were all the scientist strove for, our discoveries and advance would be of a low order. Indirectly, the close study and wide experience with reagents and methods has led to many useful results, but we need not linger over this. Throughout all the period during which Ni. an Co. have been known, there was no ready and direct method of separating them; but a few

years since, on an unsuspected corner of the reagent shelf, an organic compound α-nitroso β-naphthol was found to instantly and completely separate them from each other. Such being the case, we may some day expect research to be rewarded and the mysterious doors to be opened.

I must now, however, in the development of my plan, state the methods most in vogue for separating any rare earth from a mixture of them. Suppose we have a mixture of all or nearly all of these earths, and this is the state in which we usually get them from the minerals containing them, and that we have, say 5 litres, in solution. We remove 10c.c. and precipitate all the earths by means of a standard solution of ammonia, noting carefully the exact amount required. From this can readily be calculated the amount necessary to precipitate the 5 litres. This being determined we take enough of a somewhat weak solution of ammonia to precipitate one-tenth of the earths and add it as rapidly as possible, with violent agitation, that it may be brought in contact with as large a portion of the solution as possible at once. This precipitates the most basic portion to a large extent. The mixture is allowed to settle and the supernatant liquid is drawn off; after which the precipitate is carefully washed and the washings are added to the liquid. This is again treated with ammonia, another tenth being thrown down. This process is repeated till the entire amount is precipitated. The first two or three precipitates are then united, then the next two or three and so on, and each group is again treated in a similar manner, till after some hundreds of repetitions there collects at one end of the series a considerably basic, and at the other a considerably acid, hydroxide. The various precipitations are checked by atomic weight determinations, and when an hydroxide is obtained in which the entire ten precipitates yield identically the same atomic weights, it is considered as an elemental earth, the argument being that no two elements will be at all likely to possess the same basic qualities. This will probably give you an idea of the time expended and the difficulty experienced in working in this field. Ammonia is by no means the only reagent so employed, but every one likely to produce different qualities of precipitates is tried.

Here, then, we have a group of elements whose compounds act differently toward chemical reagents from all other bodies. They resemble the alkalies and alkaline earths, *i. e.*, the Li. and Gl. families in their action toward H_2S, and the B. and Fe. families in their action towards $(NH_4)_2S$. They resemble the last two and all the other families except the Li. and Gl. families in their action toward NH_4OH. They

differ from all other elements in their action toward Oxalic acid. All oxalates are more or less soluble in acids; but outside the rare earths, the solubility is perfect. Calcium oxalate is considered an insoluble precipitate, but the reaction must be alkaline, the least trace of mineral acid setting up solution, the presence of oxalic acid prevents the precipitation of alumina, etc., but here we have a group which precipitates at once to oxalic acid or to a soluble oxalate in an acid solution, and if only faintly acid, say 1 or 2 per cent, the oxalates separate out completely, in fact a mere trace is soluble in a 5 per cent acid. Thus we can separate them easily as a group. If we render the supernatant liquid more and more acid, we can gradually get out portions of which the member first removed will differ considerably from that last removed, but probably not in a lifetime would one get one member absolutely free from every other member. Therein lies the difficulty, and so it is with every reagent to some degree. Some reagents shorten the work, and a number of persons working together, by being able to do more work get more rapid results, but the field is one of great difficulty.

There are other troubles, however, in the path of the investigator in these fields. All who have worked practical chemistry are aware that there are qualitative tests by means of which we can detect the presence or prove the absence of any particular metal or acid. Ammonia acts towards a solution of a copper salt as it acts towards nothing else. HCl. gives a white precipitate to silver as well as to lead and mercurous salts, but the chloride of lead is soluble in hot water and can be washed out, that of silver dissolves in ammonia and can in turn be removed while at the same time the mercurous chloride turns black but remains insoluble owing to the formation of a compound with the ammonia so that it is easily determined whether neither one, two or three, or which one is present. This makes the work of Mosander the more remarkable, as in his time there was nothing to enable him to suspect the different rare earths except abstract reasoning from slight color changes.

In 1858, however, Gladstone, the London chemist, noted on examining the light, which had passed through a solution of Didymium salt, with a spectroscope, that in certain parts of the spectrum there were dark color bands although the solution might be perfectly colorless. These have been proved to be due to the absorption of some of the light while passing through the solution. This fact of absorption is not of itself very remarkable. All colored solutions absorb more or less light, $KMnO_4$

solution, purple in color, absorbs certain light, colored glasses absorb light, etc., but all manganese salts, colored or uncolored, do not absorb light, nor if the solutions are of different colors, though of the same element, do they absorb the same portions of light. Gases absorb light, and on looking towards the sun with a spectroscope, faint bands are to be seen in the spectrum. Certain metals when heated, give certain varieties of light as, Na yellow, potassium blue, copper green, etc., and these same substances, converted into vapour, absorb the same light that in their white hot condition they emitted, but here we have the phenomenon of a colorless solution acting like a colored solution or like a gas. This of course gave a test for Di. as soon as the absorption bands were mapped and thoroughly defined. This to the rare earth chemist was a valuable discovery, but in its application it calls forth the highest skill of the chemist, for he must be able to fix upon the exact bands and say this is given by Di., this by Er., etc. Here is displayed a fresh peculiarity of the rare earths, for while there are no elements outside these which give bands, there are several within the group which do, viz.,—Di. gives 31 well defined bands, Sm. 12 not so well defined (and some of them disputed, the subject is being thoroughly investigated by Boisbaudran), Ho. 16, Er. 8; Yb. shows none in the visible part of the spectrum, but many have been mapped in the ultra red portion.

The qualitative application of this knowledge is as follows:—A mixture, say of Di. and Ce., is to be freed from Di., this being most familiar to myself. The oxalate, first well-washed in dilute HCl, is dried and ignited to the condition of an oxide, and then dissolved in HNO_3 and a preliminary examination is made with the spectroscope to make sure of the presence of Di., and incidently to judge of its abundance. The intensity of that band known as the α band is especially noted. It lies near the Na. band (yellow.) The mixed solution is then subjected to one of the separation processes, and as strong a solution in as deep a layer as possible, is examined with the spectroscope and the intensity of the α band is noted. This process is repeated until the most intense band has entirely disappeared. When I remind you, however, that the removal of the Di. by what was undoubtedly the best method known until lately, required a seven times repetition the Di. bands growing gradually fainter and dying out one by one until what had been the most intense finally faded entirely from view it will be seen that this fractional method forces one to the conclusion that possibly all the Di. has not

been removed, but that a more powerful spectroscope in the hands of very experienced men might rediscover, in what appeared free from Di, traces of it yet present. This has actually happened more than once, and was what caused Prof. Dennis and myself to lay so much stress upon our new separation process, for the removal of Di. from Ce. We believe that the new method removes the Di. at once and entirely; for with the best spectroscope at our disposal we could find no trace of Di. The process in other words is not fractional but immediate. I can perhaps illustrate this better by an example, familiar perhaps to all of us. Ferro- and Ferri-Cyanides of K. long served as accurate tests of Fe., later Potassium Sulphocyanate was found to detect ferric Fe, when the Cynanides failed to do so. This reagent gives to a solution containing ferric Fe. in solution, a blood red or, in weaker solution, a wine color. When, however, some chemist proposed to add ether to the solution after testing for Fe. and failing to obtain a color, he found on closing the test-tube, and shaking violently that from a solution that was colorless after adding KCNS, a red color was extracted by the ether. This of course gives a very dolicate test for Fe., a delicacy unsought for a few years since. The Di. test is probably not so delicate at present.

But just here comes in one more of the evil features of the rare earth work, for the test that serves to prove the absence of Di must serve also as the test for La. which has no absorption bands, since La. being more strongly basic than Di., when the latter is known to be removed the former must have been previously gotten rid of. Of course the spark spectra could be employed, and, unless some easier method is discovered, must be employed in very accurate work, but it is tedious and requires special apparatus and precludes all workers, but those who have the advantages of the finest university laboratories, or are themselves wealthy. It needs, moreover, a much longer training than is needed to use the absorption band method. It is seldom employed as a test. The other method, applicable also in every case, but slow and requiring the very highest chemical skill to ensure results is to make equivalent weight determinations. This has so far been done gravimetrically, but methods are being sought by which it may be done volumetrically, which will be a great shortening, and in skilled hands, if the methods are good, will yield excellent results.

Having now given a fair idea of what the rare earths are, how they act chemically, and the difficulty of experimental work with them, I will

proceed to speak of their occurrence, and then give some reasons for the immense interest any work in this line creates in the advanced chemical world. For a long time the earths were supposed to be what their name implies, really rare. There were reasons for this opinion. The earliest known specimens were among the last discovered in that period of intense chemical activity, the end of the 18th and the beginning of the 19th centuries, a time honored by such names as Lavoisier, Davy, Cavendish, Priestly, Dalton, Scheele, Berzelius, Vaquelin, Klaproth, and the elder Rose's. The lack of refined chemical methods, especially among those who had most to do with new minerals, the lack of sharp qualitative tests, and the fact that in ordinary analytical methods it was easy to mistake these for iron or alumina, all tended to the strengthening of this belief. Still during all this time the ablest chemical minds turned again and again to the subject, and from pure love of the truth sought for the solution of their mysteries. There is scarcely a great chemist who has not at some time attacked the knotty question, and seldom, as we must acknowledge, did they obtain other than negative results, and, as you know, these are seldom published—a mistake, by the way, as we could avoid many pitfalls and save valuable time did we know the experience of others along the same lines. When the discoveries of Mosander were published, new interest was created, and that indefatigable worker, Rammelsberg, better known possibly to the mineralogical than to the chemical world, examined many rocks for traces of these elements. Thanks to his efforts, seconded by Hermann, Wöhler and many other chemists, as their time permitted, and to the improved general as well as particular methods, the rare earths were found here and there and, we can now add, almost everywhere. It would now seem that like Fe. they are everywhere present, only in very small quantities. Zr. is lately, by microscopic method, proved to be present in every rock. Ce. is a common companion of Zr., and with Ce. there are always present La. and Di. and usually others. Norway and Sweden, the land in which they were first discovered, produce but small amounts of them now. In Brazil Monazite sand can be shovelled up on the seashore, it is a phosphate of Ce., La., Di., and Th. In Llano Co., Texas, Sipylite is found in considerable quantities, as also Gadolinite and other similar minerals. Along the Atlantic seaboard from Virginia to Georgia, in New Jersey and New York, in Massachusetts, in Renfrew Co., Ont., and elsewhere in Canada, in Colorado, along the Andes, in India, and Australia, along the Ural Mountains, in Germany, in England, and undoubtedly in many

other places when thorough investigation has been made. From Dana's latest published textbook of mineralogy, the unabridged edition of 1892, I, a few years ago, made out a list of 62 minerals which contain the Ce. group, so-called, viz. :—Ce., Di., and La. Never did I find our own province recorded as having produced a single specimen. This I do not believe to be correct, when so many rare and peculiar minerals exist here, where there are rocks of every geological age, and where every one of the ordinary elements except the Pt. group has been found, I cannot but believe that the presence of the rare earths has been overlooked. I am not conversant with Prof. Hind's papers, but it would be interesting to know whether, in his numerous analyses of the minerals of the Province, he ever sought for the presence of the rare earths. It would not be surprising if he had, and yet failed to find them, for the methods of testing for them are not given in the ordinary text books of analytical chemistry and in the larger qualitative works of Prescott and Johnson, Fresenius, etc., very little attention is paid to them ; they are mentioned in footnotes or in fine print, and only the most advanced chemists are likely to pay any attention to them. This is partly because they are of little importance to the ordinary analyst, and partly because the field is so difficult ; and advanced chemists will of course go to the original papers. Still this all tends to the overlooking of these earths. A chemist might even take the B. Sc. degree, with Chemistry as his main subject, in any English or American university and know little beyond the fact of the existence of and the probable rarity of these elements. He might even obtain a Doctorate in Chemistry, and, unless his attention were especially called to the subject, know little of them. They are out of the ordinary line of travel. I am not saying this merely to fill in the time and make a long paper, as some may be tempted to think, but to show that, even if Prof. Hind did not look for these elements, and I am strongly inclined to think he did not, that it would not be casting any reflections on his skill as a chemist, nor slurs on his reputation as an analyst. They are considered out of the line of any one except the chemist who specializes along these lines. I need scarcely say that this is a mistake, to some extent at least. None but an advanced specialist in inorganic chemistry is likely to work with the earths, at least until more is known concerning them, but any ordinary chemist might easily look for their presence. I trust, if any especially heavy minerals or peculiar ones are known to members of this institute, the same being of provincial origin, they would apply the simple test I have mentioned—precipitation by oxalic acid in

weakly acid solution, or send a small sample to me when I would be pleased to report the presence or absence of the earths. If the suspected mineral contains Di. a direct vision spectroscope will detect it at once by simply looking through it at the mineral. Now, finally, to give a little attention to what, according to my heading, ought to be the most important part of my paper. Why are the rare earths of especial importance to the chemical world? Why did such a chemist as Krüss give up so much of his too-soon ended life to their study? Why do Brauner, Nilson, Cleve, Boisbaudren, Debray, Crookes, and scores of lesser lights give all the time they can spare to solve the mystery? Why did Crookes, when a few pounds of Sipylite, so far a rare mineral, were found not long since in Texas, cable to reserve it all for himself at any price? Why did chemists like Marignac and Bunsen in the latter part of their life, with all their vast accumulations of scientific knowledge and their tried analytical skill, give their finest work to the unravelling of this problem? For two reasons chiefly. The desire to discover the truth, the aim of every true scientist, coupled with the knowledge that here was a field to test the mettle of the bravest and ablest, but also, and perhaps more important for proving the falsity of, or on the other hand, rounding out the periodic system of the elements.

The scientist ever seeks to bring the subject which he studies under the power of mathematics. He recognizes that this is the most powerful of instruments with which to work. All branches of science have, however, to pass the observational stage before laws can be deduced and classifications brought about. Though several chemical facts can be discussed mathematically, the subject as a whole is but emerging from the observational stage. Botany is still in this stage as also Bacteriology, the latter, of course, far behind the former; and possibly it may be claimed that the former is nearer mathematical control than chemistry. Its classification is certainly superior, but its classification, at least the one now in use, is a superficial one and readily arrived at. Not so Chemistry. The atom and even the molecule, evades our grasp and laughs at our skill, the balance alone conquers them and even here we grasp them but lightly. Their existence, even, is being disputed so evasive are they, and those who would claim their existence are confronted by metaphysical reasonings to prove them only hallucinations. It has been a long and weary search since Dalton propounded his atomic theory but the reward seems nearer. Thompson, or I should say Lord Kelvin, is fixing

limits for their size and weight, while Mendelejeff and Meyer have propounded a theory of classification. The subtle points will yet be chained and their properties scrutinized.

For a long time, ever since chemistry became a science in fact, the need of a proper method of classification has been felt. There was no order, no opportunity therefore to apply mathematics, there was no comprehensive and easy means of grasping the subject, each element and almost every compound must be studied by itself. So greatly was the need felt that, whenever a new property common to a few or several elements was noticed, attempts were made to make it the basis of a classification. Berzelius thought he had discovered a method but this was soon found wanting, not being founded on sufficient data; when Faraday discovered the relations of the elements to the poles of the electric battery it was supposed to be settled, but this soon showed itself as a common property for all, extending from one end of the list of elements to the other and giving no special point where it could be said one class ended and another began, it soon resolved itself into the older metals and non-metals, basigens and acidigens and so failed,—it was founded on the too narrow basis of a single property. Inklings of the truth were, however, obtained from time to time. Dobereiner seems to have made the first suggestion which has led to the present system. He classified many of the elements into triads, taking as a basis a property certainly common to all, viz,—weight. He first noted that in many cases the weight of one element was the mean of that of two others usually resembling it, secondly, in other cases three elements with very similar properties possess very nearly equal atomic weights, viz,—Li., Na., K., and S., Se., Te., for examples of the first and Fe., Co., Ni., and Rl., Rh., Pd., as examples of the second. The comparisons were continued by Pettenkofer, Dumas and others, clearer and still clearer signs of universal order appearing as the atomic weights were more and more accurately calculated. Newlands was able between 1860 and 1866 to arrange the elements in octads, but the gaps were so many and the table so fragmentary, and moreover so many elements were forced to stand aside that his friends jocularly suggested that he try arranging the elements according to the first letters of their names. Had Newlands possessed the full courage of his convictions England would have received the credit of the greatest advance in Chemistry since Liebig and Wöhler founded Organic Chemistry. It was left, however, for bolder minds. Lothar Meyer, and

Mendelejeff attacked the question more courageously. The former was probably the first in the field, but the latter must be considered the true parent of the system, for while the former made up a table and pointed out many resemblances between the elements, some of which indeed escaped Mendelejeff, the latter not only proposed a table of the elements, but boldly altered the atomic weights of certain of the elements when they did not conform to his table, and did not merely lay them one side to await what the future might decide concerning them. He did more than this, he said in effect "My classification is correct but there are many spaces where elements are wanting; this does not effect the table it simply means that some elements are as yet undiscovered. I shall describe three of these," said he, "and without claiming to be a prophet, will indicate where they are likely to be found." He named them provisionally Eka-boron, Eka-silicon and Eka-cadmium. Within a few years two of these were discovered and their properties agreed almost identically with those which he had suggested. He altered the atomic weight of Ce. from 92 to 140, U. from 120 to 240, and made other changes. His prophecies were unnoticed or jeered at; his suggested changes were ridiculed. He fought his cause single-handed but his triumph was complete, and came quickly. In less than ten years from his announcement of the Law, the specific heat of Ce. was redetermined by means admitting of very slight error, and the atomic weight was proved to be 140 or nearly so, much nearer 140 than 92. Uranium was by the same means soon proved to have the proposed weight, viz,—240. Chemists then began to examine his predictions more respectfully and were soon surprised (if chemists are ever guilty of surprise) when in 1879-80 Nilson, followed by Cleve, proved the existence of Eka-boron under the name of Scandium; and when in 1886 Winkler proved Eka-silicon to exist as Germanium, Mendelejeff's triumph was complete. Few now doubt the truth of the law, and it has become a powerful weapon in the hands of the investigator. The line of the classification is complete, the actual basis is probably not known as yet, it may be the atomic weights, as is most usually assumed; it may be a common element as is being quietly proposed, though as yet unsupported by experimental evidence; it may be some property as yet unsuspected but that the order is nearly or quite correct no one doubts.

But where comes in the importance of the rare earths? A glance at either form of table will show blanks. No one doubts that these will

be filled in. Whence? Undoubtedly in most cases from the rare earths. Ni. and Co. according to Krüss' work seem to conceal an element which may be found to have an atomic weight of about 100 and the earths conceal many. Within a few years Di. has been split up, one component showing absorption bands and the other failing to do so. As already pointed out, two earths once considered simple have yielded at least twelve and when the means of the separation, when the reagent or method is finally found, then the vacant spaces will be filled.

But it is not only that the rare earths will probably fill these vacant spaces in the table that gives them importance, their similarity is such in regard to action towards reagents that they seem to run contrary to the law. If so many of them are of the formula $R_2 . O_3$, they cannot be distributed over the table but will mass in groups and destroy the table. Of course if the table is incorrect the sooner it is proven the better so that the mind of the inorganic chemist may be directed elsewhere for comparisons, and it is just possible that in this very thing lies the importance. Still the periodic law seems to rest on good foundation.

The great importance then seems to lie just here. These rare earths exist, of this there can be no doubt. The best chemical skill that the world has possessed have been working upon them for over a century, and have so far been unable to confidently state their number and actual properties. The more work that is put upon them the greater the number of them seems to be. If the ones now claimed are all real there is not room for them in the law, *i.e.* spaces are wanting for their apparent weight. Until this question can be settled a mystery hangs over this portion of the Periodic system. The unravelling of this may work an entire change in our ideas of the elements. Their subtle resemblances have suggested to me more than once, while pondering over them, that in these lies the key to the simple elements which many chemists believe to be the foundation of the so-called elements. As in the Marsh-gas series the time comes when the Hydrogen-Carbon chain becomes too heavy for the bonds or affinity to sustain the weight, so in our inorganic field something of the same kind may result. The hypothetical elements may in certain numbers of atoms or in certain arrangement of atoms yield such similar properties that the one compound is distinguishable with difficulty from another. Time and high chemical skill alone can unravel the mystery, but so long as things remain as they are there remains an element of uncertainty in the periodic law. We have

fortunately the key to the organic compounds and can read causes for resemblances and differences. The study of these has been of vast importance to the commercial world, but here is a field unwrought, not for want of workers, but by the very difficulty of the work challenging attack. I believe that here lies the key which once found will unlock many of the mysteries of the chemical world. And one thing is certain, the skill required to explain the mystery will give such power and grasp to the discoverer that he will with ease unroll the panorama of the elemental field and place it under man's open vision.

The unfolding of the mystery of the rare earths is not only necessary, then, to complete the Periodic system but they evidently conceal some chemical truth not known or imperfectly understood, and so not properly applied by chemists. Moreover, judging from the number of elements claimed as rare earths and their resemblance to each other, it is possible that they will overcrowd the Periodic system and compel its modification or rejection. In either case the examination will lead to large additions to the world's scientific knowledge, to *truth*, the aim of all true scientists.

The subject was discussed by several of those present, and a vote of thanks was presented to Dr. Magee.

Watson L. Bishop, Esq., exhibited a collection of Nova Scotian birds' eggs, and made remarks thereon.

Seventh Ordinary Meeting.

Legislative Council Chamber, Halifax, 13th May, 1901.

The President in the chair.

On motion of Prof. E. Haycock, seconded by Prof. E. MacKay, it was resolved that the the N. S. Institute of Science recognize as subordinate branches, local organizations of its members in particular sections of the Province, formed for the purpose of encouraging scientific study and investigation; providing that such orgonizations are active and report yearly at the annual business meeting of the Institute. Members of such recognized branch societies who pay a yearly fee of one dollar to the parent society shall be entitled to all the rights and privileges of ordinary members of the Institute.

The resolution was referred to the council with directions to carry out the terms of the resolution, and to make any further recommendations thereon to the business meeting.

The following two papers were read by title :—

(1). Further Explorations in the Torbrook Iron District.—By EDWIN GILPIN, JR., ESQ., LL. D., &c.

(2). Discription of Fish-like Tracks from the fine-grained Siliceous Mudstones of the Knoydart formation (Eo-Devonian) of Antigonish County, Nova Scotia.—By HENRY M. AMI, ESQ., D. Sc., of the Geological Survey of Canada. (See Transactions, p. 330.)

PROF. ERNEST HAYCOCK, M. A., of Acadia College, then read two papers :—

(1). The Geological History of the Gaspereau Valley, N. S. (See Transactions, p. 361.)

(2). Fossils, possibly Triassic, in Glaciated Fragments in the Boulder Clay of King's County, N. S. (See Transactions, p. 376.)

These papers were discussed by the PRESIDENT and Messrs. A. MCKAY, POOLE, and DOANE.

A vote of thanks was presented to PROF. HAYCOCK for his interesting communications.

The following papers were then presented :—

(1). Phenological Observations for 1900.—By A. H. MACKAY, ESQ., LL. D., &c. (See Transactions, p. 379.)

(2). Rainfall Notes, Nova Scotia.—By F. W. W. DOANE, ESQ., C. E. (See Transactions, p. 399.)

The Council was authorized to receive as having been read by title, such papers as may be presented too late for this meeting. [Under this resolution a paper subsequently submitted by D'ARCY WEATHERBE, ESQ., C. E., on "Recent Developments with the Calyx Drill in the Nictaux Iron Field," was accepted by the Council. (See Transactions, p. 350.)]

HARRY PIERS,
Recording Secretary.

SKETCH OF THE LIFE OF J. M. JONES.

(See Frontispiece.)

John Matthew Jones was born at Frontfaith Hall, Montgomery, Wales, on 7th October, 1828. He was a son of Admiral Sir Charles Thomas Jones, K. C. B., his mother having been formerly Miss Jane Helen Satton.

In 1840 he went to Osmestry in Shropshire, England, a grammar-school under the superintendence of the Rev. Stephen Doane, and subsequently he received instruction from a private tutor, the Rev. John Whitly, rector of Wargrove near Warrington, Lancashire. He became a barrister of the Middle Temple, London, but being possessed of independent means, did not practice his profession. For some time he was a captain in the Royal Montgomery Rifles.

In June, 1850, while on his way with his brother to the latter's shooting-box in Scotland, he was wrecked in the steamship "Orion" off Portpatrick. Over one hundred persons were drowned, but Mr. Jones and his brother were among those who were saved.

He came to America about 1854 with his eldest brother who was flag-lieutenant to Admiral Milne, intending to shoot in the Rocky Mountains. He landed at New York, but was only able to proceed as far as London, Ontario, when an outbreak of cholera forced him to go to Halifax. He finally decided to reside in the latter town where, about the same time, his relative the Earl of Mulgrave, was stationed as governor.

He spent some time in the Bermudas, where his researches into the natural history of those islands resulted in the publication about 1859 of a volume entitled "The Naturalist in Bermuda."

At Halifax he resided for some time at "Ashbourne," a charming country place surrounded by fields and woods, at Dutch Village not far from the city. Near him lived the late Andrew Downs, well-known as an ornithologist, whose grounds were arranged as a zoological park; while in the city were several men who were beginning to take a keen interest in the study of the natural history of Nova Scotia.

In this country home, Mr. Jones's opportunities were excellent for observing nature and making extensive collections of the fauna of the province, to the investigation and gathering of which the greater part of his time was given. At "Ashbourne" he had a private museum

in a building erected for the purpose, and in 1866 the number of specimens it contained was estimated at from seven to eight thousand.

He was an enthusiastic collector, and the cabinets of the British Museum, the Smithsonian Institution, and the Provincial Museum of Nova Scotia, were enriched by his generosity. He took great interest in the international exhibition at London in 1862, the provincial fisheries department being placed under his management.

During the winter months Mr. Jones usually resided in Bermuda, at his place called "The Hermitage," Smith's Parish, and gave further attention to the study of the natural history of that locality.

Mr. Jones married Mary, daughter of Colonel W. J. Myers of the 71st Highlanders, of Halifax, by whom he had seven sons and four daughters.

He was a Fellow of the Linnean Society of London, an original Fellow of the Royal Society of Canada, and one of the founders and ablest supporters of the Nova Scotian Institute of Natural Science, of which he soon became president.

Mr. Jones died on his sixtieth birthday, 7th October, 1888, at 114 Tower Road, Halifax.

Among his publications may be mentioned the following :—

The Naturalist in Bermuda ; a sketch of the geology, zoology and botany of that remarkable group of islands ; together with meteorological observations. Illus. London, 1859 (?), pp. 192.

Extract from the Bermuda "Royal Gazette," relating to the recent capture of a large species of Gymnetrus.—*Proceedings of the Zoological Society*, (Lond.), 1860, (part xxviii), pp. 185-187.

Contributions to the Icthyology of Nova Scotia.—*Transactions N. S. Institute of Natural Science*, vol. i, pt. 1, pp.45-54; 1863.

Kjoekken-moedding in Nova Scotia —*Smithsonian Report*, 1863.

Contributions to the Natural History of the Bermudas: Part 1, Mollusca, —*Trans. N. S. Inst. N. Sc.*, vol. i, pt. 2, pp. 14-26; 1864.

Contributions to the Natural History of Nova Scotia: Reptilia.—*Ib.*, vol. i, pt. 3, pp. 114-128; 1865.

Notes on certain species of Nova Scotian Fishes.—*Canadian Naturalist, N. S.*, vol. ii, pp. 128-135 ; 1865.

On the Geological Features of the Bermudas.—*Trans. N. S. Inst. N. Sc.* vol. i, pt. 4, pp. 18-26 ; 1866.

A Fortnight in the Backwoods of Shelburne and Weymouth. *Ib.*, vol ii, pt. 1, pp. 48-60; 1867.

Contributions to the Natural History of the Bermudas. [Coralliaria.]—*Ib.*, vol. ii, pt. 2, pp. 7-16; 1868.

On some of the Rarer Birds of Nova Scotia.—*Ib.*, vol. ii, pt. 2, pp. 70-73. 1868.

On *Hyla Squirella*, a Batrachian new to the Province.—*Ib.*, vol. ii, pt. 2. pp. 101-102; 1868.

[Nova Scotian Lepidoptua. By Rev. Chas. J. S. Bethune.] With, additional notes by J. Matthew Jones.—*Ib.*, vol. ii, pt. 3, pp. 78-87; 1869.

Nova Scotian Coleoptera. Part I.—*Ib.*, vol. ii, pt 3, pp. 141-155; 1869;

On the Laridæ of the Nova Scotian Coast.—*Ib.*, vol. ii, pt. 4, pp. 52 58; 1870.

Notes on the Marine Zoology of Nova Scotia.—*Ib.*, vol. ii, pt. 4, pp. 93-99; 1870.

Review of Nova Scotian Diurnal Lipidoptera.—*Ib.*, vol. iii, pp. 18-27 & 100-103; 1871 & 1872.

Notes on a small and remarkable Lophioid recently taken off Halifax Harbour.—*Ib*, vol. iii, pp. 103-105; 1872.

On the Vegetation of the Bermudas.—*Ib.*, vol. iii, pp. 227-280; 1873.

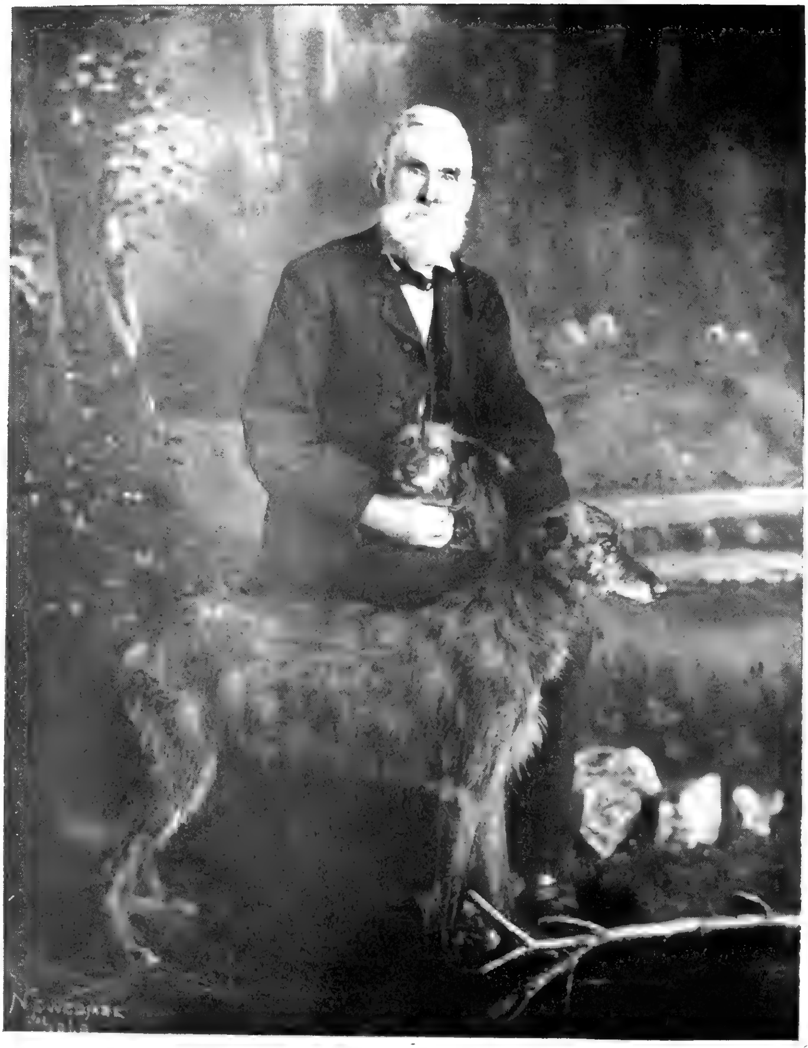
The Visitor's Guide to Bermuda; with a sketch of its Natural History. London and Halifax, [1876 ?] 12mo., pp. i-xii and 9-156.

Mollusca of Nova Scotia (corrected to date, 1877).—*Trans. N. S. Inst. N. Sc.*, vol. iv, pp. 321 (misprinted 421)-330; 1877.

List of the Fishes of Nova Scotia.—*Ib.*, vol. v, pp. 87-89; 1879.

With Goode (George Brown), ed.—Contributions to the Natural History of the Bermudas. Washington, 1884.

H. P.



Andw. Downs

(See page cii.)

PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1901-1902.

FIRST ORDINARY MEETING.

Legislative Council Chamber, Halifax, 7th November, 1901.

The PRESIDENT, DR. A. H. MACKAY, in the chair.

It was announced that AVARD V. PINEO, ESQ., barrister, Wolfville, and PROFESSOR FRANK R. HALEY, Acadia College, Wolfville, had been elected associate-members.

R. W. MCLACHLAN, ESQ., of the Numismatic and Antiquarian Society of Montreal, read a paper entitled : " A Talk on Roman Coins," illustrated by a number of specimens belonging to the lecturer.

A. H. COOPER PRICHARD, ESQ., numismatist, exhibited and described a series of Roman coins belonging to the Provincial Museum of Nova Scotia, and drew attention to the desirability of increasing the coin collection of that institution.

The subject was further discussed by the PRESIDENT, and MESSRS. R. R. MCLEOD and W. L. PAYZANT.

On motion of MR. MCKERRON and REV. R. LAING, a vote of thanks was presented to MR. MCLACHLAN.

Annual Business Meeting.

Legislative Council Chamber, Halifax, 9th December, 1901.

The President, Dr. A. H. MacKay, in the chair.

Presidential Address.—By A. H. MacKay, LL. D., &c.

Gentlemen,—Since our last annual meeting we have lost some of our members. It is a tribute to the constitution of things which every human organization has to pay.

OBITUARIES.

On the 5th of March, Dr. James Ratchford DeWolfe, who was a member from the first session of the Institute in 1863, and who bore his share in its administration as an officer, died in his 82nd year. He was the son of the Hon. T. A. S. DeWolfe, at one time a member of the Lord Falkland administration of the Province. He graduated from the University of Edinburgh, and came to Halifax in the year 1845. In 1857 he left a very lucrative practice to take charge as its first Superintendent of the Provincial Hospital for the Insane. Under his directing genius the institution took rank as one of the best administered of its class. While fulfilling all the duties of a leading citizen for so many years, he was always a staunch friend of the Institute of Science, in which he took an interest from its institution to his death. Not being able to be present at one of our meetings not very long ago in which the subject of ventilation of public buildings was being discussed, he supplemented the report of the discussion reported in the morning papers by a full and ably presented discussion of some points which he had demonstrated in his own experience, which he sent me for consideration, with special reference to the ventilation requirements of the Provincial Normal School. In him we have lost the last member on our list who joined the Institute during its first year.

Captain William Henry Smith, R. N. R., F. R. G. S., who was a member from the year 1889, died on the fifth of May, in the sixty-fourth year of his age. He was born in Kent, England, was educated at Canterbury and Greenwich, entered the Allan steamship service during the Crimean War, and was present at some of the engagements,

and afterwards successfully commanded the Allan steamers, *St. Geo ge*, *Hibernian*, *Circasian*, *Peruvian*, *Sardinian* and *Parisian*, and succeeded Captain Wylie as Commodore of the Allan fleet. He was appointed a lieutenant in the Royal Naval Reserve in 1867, and on leaving the steamship service was made Chairman of the Board of Examiners of Masters and Mates, Commissioner for enquiring into wrecks, and one of the nautical advisers to the Government of Canada. He compiled some valuable nautical distance tables, and was a valuable contributer to the press on nautical matters of public importance.

Rev. Moses Harvey, LL.D., F. R. G. S., F. R. S. C., who was a corresponding member of this Institute since 1890, died on the third of September, eighty-one years of age. He was born at Armagh, Ireland, educated at the Royal College, Belfast, and came to Newfoundland in 1852, and was for 26 years pastor of St. Andrew's Church in St. John's. In 1878 he retired from the ministry for the greater leisure of literary and scientific work, in which he became the most distinguished representative of that island. Apart from his published works, he contributed since 1869 a large number of articles and sketches on the resources of Newfoundland, to the leading newspapers and magazines of Britain, Canada, and the United States—sufficient to make many volumes. The best known of his published works are, "The Characteristics of the Present Age," "Thoughts on the Poetry and Literature of the Bible," "The Testimony of Nineveh to the Veracity of the Bible," "Lectures on the Harmony of Science and Revelation," "Lectures on Egypt and its Monuments," "Lectures Literary and Biographical," "Cormack's Journey Across Newfoundland," "Across Newfoundland with the Governor," "Newfoundland the Oldest British Colony," "Text Book of Newfoundland History," "Where Are We and Whither Tending," "Newfoundland as it is in 1894," "A Handbook and Tourist's Guide," "Newfoundland in the Jubilee Year." He also prepared the descriptive and statistical articles on Newfoundland in the "Encyclopedia Britannica" and in "Johnson's Universal Cyclopedia." He was the discoverer and first describer of that gigantic "devil-fish" which was called after him by Professor Verrill *Architeuthus Harveyi*.

WORK.

We have also lost the presence of Professor James Gordon MacGregor from our midst by his translation from the University of Dalhousie College to the Professorship of Natural Philosophy in the University of Edinburgh. He has been a member of this Institute from the year 1877, since which time he has served in all of the most important offices with a vigor which has transformed the institution in many respects. Not only did he furnish many valuable papers for our Transactions, but he prepared students who, during the last few years, added most important records of original scientific research to our list of valuable papers. And not only did he do these things, but he spent yearly a great deal of time in developing our foreign exchanges and laying the foundation of our present Provincial Scientific Library. Although not likely to be with us at our meetings, Professor MacGregor has put too mnch of himself into our Institute not to continue to be interested in its progress, and disposed to work with us still. The banquet tendered him on his departure for the "motherland" by this Institute, combined with the University of Dalhousie, was a public testimony to his services, and I am glad that the Council has added another small testimony in unanimously electing him to life membership, which we trust may be a very long membership.

At our regular meetings during the year quite a variety of subjects was discussed, the more valuable papers of which will soon appear in the volume of the Proceedings and Transactions. Mr. Poole described the new Calyx Drill; and exhibited specimens of the great cores of rock cut out by it, and at a subsequent meeting presented for examination a transverse section of *Stigmaria*, showing the cellular structure of its central vascular bundles with extraordinary distinctness. The excellence of the preservation of this structure makes its description a valuable one for the palæontologist. Mr. Prest utilized his expedition to the Labrador coast by giving us a vivid picture of his observations on Drift Ice as an Eroding and Transporting Geological Agent. Mr. Weatherbe demonstrated the latest explorations in the Torbrook Iron District. Mr. Fletcher discussed the nomenclature of our geological formations, taking in the New Glasgow Conglomerates this time—one of the most interesting of the series on the histor-

ical development of the geological exploration of the Province. Dr. Ami, who would add still further terms to this changing nomenclature, described the fossil tracks of an "Eo-Devonian" fish found in the fine-grained silicious sandstones of the Knoydart formation in Antigonish. Professor Haycock closed up the series of geological papers by a picturesque description of the geological history of the Gaspereaux Valley, and by the exhibition of fossils—probably Triassic—in glaciated fragments of rock in the Boulder Clay of King's County

Dr. Magee represented the science of chemistry in a graphic sketch of the rare earths and their importance in reference to the Periodic Law, a feat which was made easy by his research work in this department for some years. Professor Smith followed the science into its industrial applications in the rotation of leguminous crops, and the preservation and use of turnip tops. Mr. Bishop led into the field of zoology, exhibiting and describing the habits of the star-nosed mole and its young, and on another occasion showing his fine collection of Nova Scotian birds' eggs. Mr. Doane led us into the region of meteorology in his Notes on Rainfall, and I presented, as usual, my annual compilation of phenological observations made in the schools of the Province.

PROVINCIAL MUSEUM.

During the year, the Provincial Museum, which although always the ward of the Government has always been considered to be the child of the Institute of Science, has been very extensively improved by the incessant and intelligent labor of its curator, Mr. Harry Piers. While it is being rapidly made more representative of the natural and industrial history of the Province by the introduction of new material, a great deal has been accomplished by the arrangement, accurate determination, and comprehensive but distinct labelling of the old material; so that now it is becoming not only of more value to those wishing to gain an idea of the productions of the country, but to the scientific student. The curator is not a man who merely attends during the hours the Museum is open to the public. He is always working, and when the doors are closed he works most. In no other way could the vast amount of work done during the past year have been accomplished.

The collections of coins in the Museum, many of which were neither specifically determined or generally classified, came under the

notice, last year, of Mr. A. H. Cooper Prichard, a numismatic expert for some time engaged in the Boston Museum of Fine Arts, and who prepared, under the direction of the Treasury Department of Jamaica, the coin collection exhibited at the Jamaica Exhibition of 1891. On returning to the Province this summer, after a study extending over some months, he at length completed his determinations of the various coins which are now properly and minutely catalogued. Mr. Prichard undertook this work as a labor of love, no doubt also interested in many of the curious mementoes of antiquity turning up. And it is fortunate for us, for I fear we could not well afford to pay the cost of Mr. Prichard's very thorough work. I am glad, however, to be able to intimate that the Council has just elected him to corresponding membership in the Institute as a token of our appreciation of his valuable services, and that he has graciously accepted the distinction.

SCIENTIFIC LIBRARY.

On the flat above the Museum we have our new Provincial Scientific Library, also under the charge of Mr. Piers, who deals with it as a part of the Museum. This composite collection of publications, the great nucleus of which is the original library of this Institute, has already been reduced to order. The Government has added to it modern works of science, both elementary and advanced, such books as are absolutely necessary in such a library, to the value of $500 ; and we have reason to hope that this intelligent appreciation of the necessity of stimulating the scientific development of the thought and industries of the Province will continue to be shown by a Government which has done so much to make a start in a line deemed now so essential by every progressive country.

PROVINCIAL PROGRESS.

While at headquarters the growth of our scientific equipment is satisfactory, the developmeut of the Scientific spirit appears also to be accelerating throughout the Province. Under the stimulating influence of Professor Haycock a branch or affiliated organization has been instituted at Wolfville, which is thus making a bid for the second place as a scientific centre in the Province. While the access to the library of the Institute and to publication in our Proceedings and Transactions will be of some value to the local institution, it will also tend to

develop scientific workers eventually for the central institution and thus benefit both.

In Halifax the organization of the Halifax Botanical Club last summer, under the presidency of Mr. Waddell, is another and similar sign of the times.

Throughout the province several of our county academies or high schools have now better laboratories for proper science teaching than had our best colleges not many years ago; and some of the teachers are more competent than many of the good old college professors. But the Government has not allowed the country to lead in this line of our education; for laboratories have just been completed for the Provincial Normal School which are not equalled by those of any institution in the Atlantic Provinces of Canada. We should soon begin to see signs of useful results from these practical beginnings. With laboratory extension in the high schools we are now commencing to foster manual training in the common schools; so that it is hoped our future students may have not only their minds, but their hands directed in the school room to the personal and public advantages of intelligent industrial labor, as well as to the at present overcrowded, less important, less honorable, once-called learned professions.

But while the great majority of people can understand the advantage of the scientific study of the principles immediately underlying the occupations which constitute the industrial force of the country, they are not far-sighted enough to see why we should cultivate the sciences generally—the sciences which at present appear to be unproductive. Pardon a concluding word on this point.

I think of science as the application of common sense to the discovery of the facts or truth of things around us, and the arrangement of this knowledge in some system which enables us to hold them in mind in their true relations. Science, therefore, in so far as it approaches truth and completeness in agriculture, enables us to do what will give us the best crops at the least expense; in mining to do what will lead us most directly to the valuable ore and enable us to raise it at the least expense; metallurgy, to reduce the metal from the ore most economically; in medicine, to touch the hidden cause of disease and remove it; in manufacture, to improve the product or to reduce the expense of production; in transportation, to save another minute of time or another cent per ton of freight; and so on through the

whole range of human industry. That is the kind of science in which the whole intelligent world believes in without dissent. It is the ancient Egyptian cult of utility as opposed to the ancient Grecian cult of truth for truth's sake.

I would say a word, not against the Egyptian philosophy which with the world I approve; but in favor of the Grecian ideal, not simply on account of the higher order of character and of pleasure created by it, but on account of its ultimate utility in making the development of the industrial sciences possible.

The constitution of things is so very unlike our elementary conceptions of the world even after we are some years in investigating it, that the most pious theologian as well as the neglected street Arab, without a single exception, becomes a sceptic with respect to his infantile philosophy. The fairies have taken wing and disappeared for ever, and Santa Claus with his marvelous powers over space and time and the universal laws of physics which chain puny men and boys to the ground and the dull prose of fact, drops out of the gorgeous cloud of poetry and shrivels up at last to a benevolent old man also chained to the ground.

Now, many people continue to learn more after the infantile stage has been passed; but much of what they learned had been discovered and pointed out to the world by a few others. And when all that has been discovered is known, we shall feel that the world is wider and fuller than ever we thought it before. We cannot resist the conviction that there is a great deal more to be known than we thought when we knew less. And the new things are so unlike what we were expecting from what we had previously learned, that we were looking for something else when we tripped upon the new.

Now the man who is roaming through the universe searching for truth wherever it may appear, just because he enjoys such an exercise, will some day fall upon some new thing, it may be gold, coal, or a cocoa-nut, which those digging in the potato field for the hnndredth time can never get, no matter how they may long for it. Truths picked up in the simple search for truth, arranged and recorded so that they are always henceforward accessible when their complements are found, may for years, even centuries be unproductive. The discovery of just one point more may complete the solution of an old industrial problem, or reveal a new power over nature.

MALARIA OBJECT LESSON.

As an illustration, let me follow out my example of last year, the history of the cause and prevention of malaria. No single man made this discovery. Laveran in 1880 discovered the minute *Haemamoeba* in the malarial human blood corpuscles. But five years more of work by others merely proved the truth of Laveran's discovery. Nothing was done for the business men, the soldiers, the missionaries, going into malarial regions of the world, nothing was done for the millions of natives having their life sapped by the mysterious affliction. They were suffocating themselves at night by keeping out the cool healthful night air, while they allowed the sneaking *Anopheles* to snipe them without serious protest. In the meantime Danelewsky found that the birds had their blood corpuscles affected in many cases by a somewhat similar organism which he called a *Proteosoma*. The bloods of all animals were now being searched, even the blood of lizards and snakes, but the malaria still went on from 1885 up to 1895. A tremendous amount of truth about a great number of animals was being discovered, but nothing productive. Major Ross got at length to work, but still there was nothing productive. Noticing Danelewsky's discovery of the *Proteosoma* in the blood of birds, he caused mosquitoes hatched safe and sound from eggs to feed upon birds, the Blue Jay bearing his share of it, which had the *Proteosoma* in its blood. The mosquitoes became infected. These mosquitoes infected sound birds. Now in 1898, the mosquito was falling under deeper suspicion. The mosquitoes would not be affected by sucking the malarial blood from a sick human patient, however. Nobody ever thought that one species of mosquito was likely to be more dangerous than another. Why should they? But the experiments went on with all the different species which could be found, for was it not already proven that *Culex* could infect the Blue Jay with *Proteosoma*—a bird malaria. At last species of the genius *Anopheles* were found to be capable of being infected by sucking malarial human blood. Next in 1899 it was rapidly proven by Ross and the leading scientists of other countries, that persons might sleep in the most malarial district open to the night air if the mosquito netting guarding the room remained intact; and if a person were in a mountain sanitarium and be but bitten by an infected *Anopheles* he would be soon down with the malaria.

Now came the day of glory for the fly-catcher who with his net used to frequent the town pump, a harmless man supposed to have a bee in his bonnet as well as a mosquito in his net. But from over all the world except Nova Scotia and some other provinces, these fly-catchers reported the species native to the country, so that the malarial regions of the world were soon proven to be coterminous with the range of certain species. The unproductive knowledge which had been growing for twenty years and more, now suddenly became productive with a fruition of life and health and wealth to the world.

But the end of the work of these for-so-many-years unproductive toilers with the microscope and the insignificant flies did not yet cease. A species of Culex, harmless from a malarial point of view, has been proven only this year to have been the unsuspected, but sneaking and most gigantic murder of tropical America. As Danelewsky's discovery could not have been made without Laveran's, and as Ross' discovery could not have been made without Danelewsky's, so Sternberg and Reed's could not have been made without Ross'.

YELLOW FEVER OBJECT LESSON.

Before Laveran, in 1880, demonstrated the presence of the jelly-speck parasite in malarial blood, the blood of the victim of the terrible Yellow Fever plague was being examined; but the microscope was able to show nothing which could be proved to be the cause of the disease. From the range of the fever and its retreat before cold weather, some species of musquito were suspected, and were experimented with; but the result for over twenty years was still negative. Dr. Carlos Finlay, in Havana, from 1881 to 1893, had no less than eighty-eight human subjects bitten by mosquitoes which had fed a few days previously on Yellow Fever patients from the second to the sixth day of the disease. But the results were so doubtfnl as to be negative, for only one case developed into a slight attack, while thirteen were attacks of acclimatization fever, generally at too long and irregular intervals to be deemed due to the inoculation. We now know why Finlay came within an ace of the discovery, but was still so far from it. There was a peculiarity in the facts which he never suspected, for it was not suggested by the cognate previous discoveries. Nature does not work in accordance with our preconceptions. It has its own habits, which we must discover, and we may guess a thousand times

before we hit the truth. Dr. Daniel Ruiz, in the presence of Dr. Sternberg, who is now Surgeon-General of the United States Army, in the year 1887 injected blood from the vein of a Yellow Fever patient into a healthy individual to prove whether the germ was in the blood; but even that experiment was negative—the germs in the eighth day being destroyed in the course of the disease. Still, it did not appear to be an infection carried in the air, for non-immune nurses and others were very often not attacked. And the results of the malarial demonstrations of 1899 stirred up the Havana Commission anew under the general direction of Sternberg and the local management of Dr. Reed and his staff.

Last year Dr. Jesse W. Lazear and Dr. James Carroll, two members of the Commission, allowed themselves to be bitten by mosquitoes fed on a case in its early stage. Dr. Carroll was promptly taken down within the incubation period of five days, and Dr. Lazear, who was at first bitten by the mosquito within ten days of its feeding, was not affected. But on the 12th of September last year, about a month after the first experiment, he allowed a mosquito to fill itself from his hand—one which had been fed on a patient about a fortnight before, presumably. Within five days, on the 18th of September, he took ill, and on the 25th was dead. Nine other individuals voluntarily allowed themselves to be experimented upon. In those cases when the mosquito had bitten within eight days of their feeding there was no result. The cases of infection occurred when the mosquitoes had bitten more than twelve days after the feeding on the Yellow Fever patient. Thus dawned the light of the facts on the Commission. *Culex fasciatus* when fed on the blood of a Yellow Fever patient during the *first few days* of the disease did not become capable of infecting a human subject until *after twelve days*, or more if the weather was not very warm.

Now arose the question: Is this the only manner in which this plague is spread? When infected ships have to remain in quarantine, and all clothes and fabrics have to be burned or steamed, when patrols with shot guns surround quarantined towns to prevent people flying to other places, when the tremendous expense of quarantine, delay and destructive disinfection is being endured, is it of any use when the mosquito is allowed to fiy past the shot gun of the sentry, and past the cauldron of tho disinfector, while the insignificant gnat is not even

challenged? To settle this question, the Commission formed an extensive camp in Cuba, not very far from Havana, called after their first martyr for the cause of science—which is the cause of humanity—Camp Lazear. Special buildings were put up for various purposes, and the strictest regulations were enforced, with every action tested and recorded.

On the 30th of last November, three men who never had Yellow Fever agreed to go into one of the little cottages, which was furnished with doors and windows perfectly protected from mosquitoes by a fine wire netting or gauze, every night to sleep, for twenty nights. During the day they remained in their own quarantined tent near by. In this cottage, which was kept up to tropical heat, were the clothes and bedding taken, soiled, from beds of Yellow Fever patients. These clothes they packed away in the morning and opened out at night, and slept in. On the 19th of December they came out all right, and after quarantine for five days were allowed to go at large, while another set, consisisting of two volunteers, tried the experiment for the next twenty days, and still another set for the next twenty days, from January 11th last to the 31st. These volunteers excelled in their attempts to take Yellow Fever from soiled clothing within their net-protected cottage. Boxes of filthy clothing, stained wich blood and vomit from the Yellow Fever hospitals, were opened up within the room, sometimes causing such a stench that they had to retire temporarily when opening the boxes. Here they slept for twenty nights, in the very clothing of those who had died from the fever. But no fever was taken during these sixty days by these five noble volunteers. This would appear to demonstrate that the mode of quarantining should be adjusted to the specific nature of each kind of disease. What may be necessary for small-pox may be altogether unnecessary for other diseases. Millions of dollars have been spent on quararanting Yellow Fever which had little more virtue than the incantations of the old red Indian medicine-men; while the real cause was practically allowed to be limited by nature, as it was in the days of the medicine-men.

But in the camp at Lazear, in another cottage, other experiments were being conducted by heroes as great as war or missionary zeal ever produced. A cottage was divided in two by a mosquito-proof netting—each half alike. Volunteers sleep in each. But in the one

apartment a few mosquitoes which, twenty days ago, fed on a new case of fever, were set free. In the other apartment was put clothing soiled by Yellow Fever patients. On the 21st of last December the volunteers entered upon their strange preparation for Christmas. On Christmas day, three days and twenty-three hours after being first bitten, John J. Moren took ill with the fever, of which in due time he recovered. Out of seven who attempted to be infected by mosquitoes, only one escaped. Of the seven who were attempted to be infected by the Yellow Fever filth in the other half, all escaped.

The result of all this was that the regulations for the treatment of Yellow Fever epidemics had to undergo a complete revolution, with the most satisfactory results. It is not found necessary to destroy all the mosquitoes of the species *Culax fasciatus*, which is the species so far found to be capable of infection. It serves the same purpose to prevent any mosquito from infection by touching a fever patient—a regulation which must be as agreeable to the patient as it is useful to the public.

SHEEP-FLUKE OBJECT LESSON.

But the mosquito is not the only dangerous carrier of disease. Any fly may carry the germs of disease by simple contact. Some of them may carry special diseases within their bodies, as in the cases discussed. It took a long time before the cause of the spread of the Texas Cattle Fever was discovered to be by infected ticks. But as soon as the discovery was made, the control of the disease was assured.

Some of the histories of disease carriers are most complicated. And I hope you will pardon me for the reference to one as an illustration of the value which may eventually come from our exploring all the corners of our country for the insignificant animals and plants found on the earth or in the water,—such work as some members of such societies as ours are always doing. without any immediate industrial or significant results.

In Britain the sheep in some localities began to die in hundreds, and on post mortem examination their livers were found to be filled with a parasitic animal about three quarters of an inch long, somewhat flat and leaf-like. It is known as the Liver Fluke or the "Liver-rot." I shall briefly sketch its life history, which illustrates my point. One fluke produces about half a million of eggs which are expelled from the

liver through the bile duct into the intestines, whence they ultimately reach the ground. The eggs would all die if they did not fall upon the earth during cold weather, when at the end of two or three weeks they may be found as minute ciliated specks swimming in the water of pools or rain puddles. These all die in ten hours if they do not find a certain species of water snail, *Limnæa truncatula*. Those which find the snail stick to it, burrow into it, and soon become encysted in a small round cell. After some time it grows and changes into a minute somewhat worm-like shape, bores through the cyst wall and enters the liver of the snail. It is now called a Redia, and it produces a number of offspring with a large head and slender tail called Cercariæ which escape into the water of the pond. They finally swim to land and climb up grass blades where they become encysted. They die here in a short time unless a sheep comes along and swallows the Cercaria with the grass. From the stomach of the sheep it enters the liver by the bile duct, thus producing the disease from which the sheep dies. The same animal appears in many different forms. First the parasite embedded in the liver ; second, the ciliated microscopic pinhead swimming in the water ; third, the cyst in the muscle of the snail ; fourth, numerous Rediæ migrating to the liver of the snail ; fifth, numerous Cercariæ migrating from the liver of the snail into the water ; sixth, the swimming Cercariæ climbing the grass blades and becoming encysted, covered with a tough skin making them look like seed or scale stuck on the blade. Let the season be hot and dry at the critical stage and the Liver-rot becomes extinct for the season. In a few years if the climate is suitable they may become numerous again. But if the water in the sheep's pasturage should be kept clear of the said species of snail, no condition of climate could keep the plague in existence. The extirpation of the snail is no easy matter, and the Fluke is more destructive to sheep in Great Britain than the Boer war is to the sheep in Africa—at least a million per annum dying from this cause.

MARINE BIOLOGICAL STATION.

We have been favored this year with the Marine Biological Station of Canada at Canso. There, several of the scientists of Central Canada were studying the inhabitants of our neighboring sea water, etc., a knowledge of which will very soon be essential in order to preserve some of our fisheries. The duties of my office have been so engross-

ing that although one of the directors, I was not able to visit the station before its close. It is to be regretted that we had no Nova Scotian student taking advantage of such a grand opportunity this season. I hope that if the station is with us next summer there may be some of us able to take advantage of the great opportunity to study effectively at least some small portion of the unknown flora and fauna of our land and water.

Whatever work we do can be recorded in our Transactions which even last year contained information deemed valuable to scientific men in other countries. Our exploration work although proceeding at a very slow rate, and although of no immediate productive value, is building up the root, the stem, the branches, and the leaves of a tree which in due time will flower and fruit, and its fruit will be for the healing of the nation. But we cannot produce the fruit directly. The course of nature is to begin with the root and branches without which there can never be any fruit.

From such considerations, I hope it can be understood, that the cult of buying the truth and selling it not, is not only good in itself as a source of the highest pleasure, but that it is also essential for the development of that utilitarian science which results immediately in bread and material power.

The TREASURER'S report was presented, and having been audited and found correct, was received and adopted. The following is an analytical statement of the expenditure for 1900-1901 :

PUBLICATION OF TRANSACTIONS :—			
Vol. X., Part 2, (1899-1900) :			
Printing and binding	$126 54		
Engravings	38 00		
		$164 54	
Vol. X , Part 3, (1900-1901) :			
Photograph for portrait (Jones)	$ 1 00		
Engraving	3 38		
		$ 4 88	
			$168 92
DISTRIBUTION OF TRANSACTIONS :—			
Vol. X., Part 2 :			
Wrappers, receipt forms, wrapping and twine		$ 11 75	
Addressing and supervising distribution		15 00	
Postage, truckage, porter, freight, boxes, insurance, expressage		18 19	
			$ 44 94
Carried forward			$213 86

Brought forward		$213 86
LIBRARY EXPENSES:		
Stamping all books and pamphlets in Library	$ 12 00	
Services, Janitor Dalhousie College	5 00	
Expressage on books received	1 72	
Truckage, removal of books from Librarian's office to Provincial Science Library	1 00	
Insurance on Library	23 10	
		$ 42 82
Calling of meetings		22 16
Advertising		8 00
Postage (Secretary's and Librarian's)		7 47
Post Office box		4 00
Miscellaneous printing (including stationery)		4 25
		$302 56

The Report on the Library was read by MR. PIERS, and was received and adopted.

PROFESSOR E. HAYCOCK presented a report from the Wolfville branch of the Institute, which had been organized on May 28th, 1901, with the following officers; President, ERNEST HAYCOCK; Vice-President, A. V. PINEO, ESQ.; Secretary-Treasurer, PROF. EVERETT SAWYER. It was decided that all members of the parent society who are also members of the branch, should form the council. Associate members are admitted to the branch on approval, and for an annual fee of twenty-five cents to help cover local running expenses.

It was resolved that the thanks of the Institute be conveyed to the HON. ROBERT BOAK and HIS WORSHIP THE MAYOR for their courtesy in granting the Society the use of the Legislative and City Council Chambers as places of meeting, and to the SECRETARY OF THE SMITHSONIAN INSTITUTION for continuing to admit the Institute to the privileges of the Bureau of International Exchanges.

The following were elected officers for the ensuing year (1901-1902):

President.—A. H. MACKAY, ESQ., LL. D., F. R. S. C., *ex-officio* F. R. M. S.

Vice-Presidents.—F. W. W. DOANE, ESQ., C. E., and HENRY S. POOLE, ESQ., F. R. S. C., Assoc. Roy. Sch. Mines.

Treasurer.—W. C. SILVER, ESQ.

Corresponding Secretary.—PROF. E. MACKAY, PH. D.

Recording Secretary.—HARRY PIERS, ESQ.

Librarian.—M. BOWMAN, ESQ., B. A.

Councillors without Office.—ALEXANDER MCKAY, ESQ., EDWIN GILPIN, JR., ESQ., LL. D., F. R. S. C., MARTIN MURPHY, ESQ., D. SC., H. H. READ, ESQ., M. D., WATSON L. BISHOP, ESQ., RODERICK MCCOLL, ESQ., C. E., H. W. JOHNSTON, ESQ., C. E.

Auditors.—WILLIAM MCKERRON, ESQ., G. W. T. IRVING, ESQ.

Second Ordinary Meeting.

Legislative Council Chamber, Halifax, 9th December, 1901.

The President, Dr. MacKay, in the chair.

The meeting was held after the adjournment of the Annual Business Meeting.

It was announced that J. B. McCarthy, Esq., B. Sc., teacher of science in the Halifax County Academy, had been elected an ordinary member.

It was also announced that the council had elected Prof. J. G. MacGregor, D. Sc., F. R. S., of Edinburgh University, a life member, and A. H. Cooper Prichard, Esq., of Boston, Mass., a corresponding member.

The President, Dr. A. H. MacKay, exhibited a condensed form of *Botrychium ternatum* found by Mrs. R. R. McLeod at Blomidon, N. S. There sterile fronds of different ages encircled the stipe of the fertile frond. The variety was provisionally named *Agnetis*, in honour of the disoo verer.

The President reported progress in consideration of the resolution of 13th May, 1901, relative to the establishment of Branch Societies.

Third Ordinary Meeting.

Legislative Council Chamber, Halifax, 13th January, 1902.

The President, Dr. MacKay, in the chair.

A paper by R. W. Ells, Esq., LL. D., F. G. S. A., entitled, "The Progress of Geological Investigation in Nova Scotia," was read by the President. (See Transactions, p. 433.)

The subject was discussed by Messrs. H. S. Poole, R. H. Brown, and Hon. S. Holmes.

The President exhibited a set of mounted plants collected in Labrador from June to August, 1901, by Walter H. Prest, Esq., M. E. (See Transactions, p. 507.)

Fourth Ordinary Meeting.

Legislative Council Chamber, Halifax, 10th February, 1902.

The President in the chair.

It was announced that Hector H. MacKay Esq., M. D., of New Glasgow, N. S., had been elected an associate member.

H. S. Poole, Esq., read a paper by Dr. H. M. Ami, entitled, "The Upper Cambrian Age of the Dictyonema Slates of Angus Brook, New Canaan, and Kentville, N. S." (See Transactions, p. 447.)

Mr. Poole presented a paper entitled, "Notes on Dr. Ami's Paper on Dictyonema Slates." (See Transactions, p. 451.)

Mr. Poole then exhibited and made remarks upon supposed worm-trails in slate from the syncline at Green Bank, Point Pleasant, Halifax. (See Transactions, p. 453.)

The subject was discussed by Dr. Murphy, Mr. Bishop, and the President.

Mr. Poole took the chair while the President read a paper by Miss A. Louise Jaggar, of Redlands, California, entitled: "Notes on the Flora of Digby County, N. S." Appended was a list of the phanerogamous flora of the county, observed by her, which was recommended to be compiled into a general Provincial Flora.

The Recording Secretary read a paper by Thomas C. Hebb, Esq., M. A., of Dalhousie College, "On a Determination of the Freezing-point Depression Constant for Electrolytes." (See Transactions, p. 409.)

The subject was discussed by Prof. Dixon.

Fifth Ordinary Meeting.

City Council Chamber, Halifax, 10th March, 1902.

The President in the chair.

The Recording Secretary read a communication from the Royal Society of Canada, inviting the Institute to appoint a delegate to attend the May meeting of the Society. The communication was referred to the council for action.

A paper by WALTER H. PREST, ESQ., M. E., entitled, "Supplementary Notes on Drift Ice as an Eroding and Transporting Agent," was read by MR. POOLE. (See Transactions, p. 455.)

Specimens of sand and gravel from drift ice on the coast of Labrador near Cape Smoky, collected by Mr. Prest, were exhibited, and described by DR. A. H. MACKAY.

The subject was discussed by Dr. Murphy.

A paper by PROF. JOHN DAVIDSON, PHIL. D., of the University of New Brunswick, entitled, "Agricultural Credit," was read by MR. MCKAY. (See Transactions, p. 458.)

The paper was discussed by MESSRS. MCKERRON, POOLE, and BISHOP.

The following papers were read by title :—

(1). On the Standardization of Hydrochloric Acid with Borax.—By R. S. BOEHNER, ESQ., B. SC., Dalhousie College.

(2). On the Determination of the Freezing-point Depressions of Dilute Solutions of Electrolytes.—By THOMAS C. HEBB, ESQ., M. A., Dalhousie College. (See Transactions, p. 422.)

HARRY PIERS,
Recording Secretary.

Sketch of the Life of Andrew Downs, Founder of the First Zoological Garden in America.—By Harry Piers.

(See frontispiece.)

Andrew Downs was born in the town of New Brunswick, New Jersey, U. S. A., on 27th September, 1811. His father, Robert, left Scotland, of which he was a native, with the intention of taking a position in Quebec, Canada. Some of his possessions having been landed at Halifax, N. S., he came here, but afterwards left for New Jersey, where he remained for some years. There he married Elizabeth, daughter of John and Catherine Plum, who was, I understand, of German descent. With recollections in his mind of the city by the sea, Robert returned to Halifax in 1825, bringing with him his family, including his son Andrew, then a lad of about fourteen.

Andrew was for sometime engaged in the plumbing business with his father, and later, on his own account. His tastes, however, were entirely of another kind, and he gradually gave more and more of his time to the study of nature, the preserving of birds and other animals and the propagation of the same, and to this work he finally devoted all his energies.

I would like to emphasize the fact that to him belongs the honour of founding the first zoological garden in America. This he started at Halifax in 1847, sixteen years before the Central Park collection at New York was opened to the public. The Philadelphia garden did not open till July, 1874, although the society was incorporated a number of years before; while the "zoo" at Cincinnati opened in 1875, that at St. Louis in 1877, and the Lincoln Park Garden, Chicago, in 1881.

Mr. Downs commenced with a piece of land of five acres, but by 1863 he had enlarged his premises to one hundred acres ("Walton Cottage"), near Dutch Village, North-West Arm, Halifax County, embracing wood and field, stream and pond, hill and valley. This

place soon became a most popular resort for the curious and for those students and lovers of natnre and good fellowship who found keen pleasure in the proprietor's company, and many anecdotes are connected with the naturalist's life in this lovely spot. The Prince of Wales, now King Edward, paid a visit to the place when in Halifax in 1860, as did nearly every notable person who came this way, including Prince Jerome Bonaparte, King Victor Emmanuel's daughter, Lord and Lady Falkland, Capt. Sir Richard Grant, and many others.

In 1864 Downs visited Europe, being complimented by a free passage across the Atlantic in one of Her Majesty's war vessels, the "Mersey," Capt. Caldwell. On this occasion he carried with him several living specimens, two cases of mounted birds and a stuffed moose, which he presented to the London zoological garden. In Europe he received courtesies from many scientific men.

On his return to Halifax his zoological garden was much improved, and the following extract from an article by his friend Charles Hallock, author of "The Fishing Tourist," and founder and proprietor of "Forest and Stream," graphically describes the place in these, its best days* :—

"I recall his premises as if it were but yesterday. From a rustic gate in the enclosing hedge a gravelled road wound under interlacing trees to a Gothic cottage over-hung with woodbines and honeysuckles, and surmounted at all points with antlers of elk and moose. This was at once the residence of the proprietor and the outpost of the realm. Beside the porch were bird houses perched on poles, whose chattering tenants hovered round, entering and departing at will. Pigeons of all sorts tumbled and circled overhead, and strange noises were emitted from a neighboring copse. Here and there were rude boxes of cocoons of many varieties, kept for experiments. Not far from the door a pair of whale's ribs and some huge vertebræ lay upon the lawn.

"Entering the house by the main hall-door ajar, we find it alive with the more delicate species of songsters. The parlors and reception

* "The First American Zoo," by Charles Hallock ; *Nature*, New York, Vol. 1, No. 10 (Jan. 4, 189), pp. 130-131. The reader is also referred to another article by Mr. Hallock, "Andrew Downs, F. R. S. [error for C. M. Z. S.], Naturalist," in *Forest and Stream*, New York, Vol. 53, No. 10 (Sept. 2, 1899), p. 184, with portrait, p. 182. In both of these papers he strongly appeals for public recognition of Downs as the founder of the first zoological garden in America.

rooms constitute a museum of natural history and art, perfect in classification and detail of arrangement,—paintings, engravings, water colors, herbaria, busts and miniature sculptures. And what a view from the verandah and bay windows! The 'North-west Arm' stretching away toward the ocean, with its bays, inlets, wooded hills, island and far-reaching points of land that are blue and only half-distinct in the hazy atmosphere of a summer day. Yonder is the devoted naturalist in his shirt sleeves feeding his poultry. He is fairly surrounded by multitudes of the feathered and four-footed tribes. Shaggy skye terriers of different colors, which have the freedom of the yard, greet our approach by rubbing their dusty paws on our boots; tumbler pigeons throw summersets in the air and plump down at our feet; pouters and fantails strut and flutter among the throngs. Chinese and Egyptian geese with huge, bulbous bills, squawk discordant notes; cranes stalk majestically; monkeys grimace and marmosets chatter in a cage close by, and a big Brazilian monkey gives a sly tug at our coat tail through the wires of his cage. There are bantams and game fowls, ducks, geese and pheasants, all of rare breeds, and for each he has a peculiar call and a handful of seeds or grain, or bread or biscuit, suited to its peculiar taste. All about the immediate vicinity are cages, coops, perches and shelter-houses, some closed on their inmates and others open for free ingress and egress. A little beyond this part of the premises, at the edge of a lawn, is a lake where China swans, odd-looking geese and ducks with uncouth topknots are playing under the douche of a fountain. Tall cranes stalk along the reedy margin, herons on one leg stand motionless among the lilypads, wood ducks skulk beneath the overhanging bushes, and wild wood birds dart in and out of the trees which fringe the border. Farther on a cascade tumbles into the lake, and the rocky basin at its foot provides cooling refreshment for a large polar bear. The stream leads to a pond above, where a seal sports and comes to the beach at call. Here are beavers, mink and otters, all suitably secured in mesh-wire inclosures. Anon we cross a rustic bridge which spans a ravine, and thence traverse a shadowy path to a bower with a table inside made of the ponderous bone of a whale's tail. Near at hand is a flower garden laid out in artistic designs, and in a clump of trees just aside are nesting birds which receive the naturalist's daily attention. Next come

enlosures for Spanish, Mexican and Virginian deer, a large yard for moose, enclosing trees for browse, others for elk and caribou, and another for black bears. And so the visitor passes on through this hundred-acre domain, with its alternate woods and open intervals, to gaze successively at the long-billed bitterns, whooping cranes, gold, silver, English and Amherst pheasants, California and native quails, eagles, hawks, foxes, lynxes, prairie wolves, owls, fancy rabbits, Guinea pigs, China sheep, Angora goats, silver-bearded Polands, Hamburg fowls, Indian and Egyptian doves, ring doves, and so on.

"In another part of the grounds is an Oriental kiosk filled with every variety of stuffed birds, live snakes, lizards and turtles, and containing an extensive aquarium.

"What particularly strikes the observant visitor is the nicety with which the habits of the creatures are satisfied by the adaptation of environment; and it is easy to perceive, from such results accomplished, what is possible for our public gardens in the United States, with sufficient area and liberal money appropriations. Certainly no existing zoological collection is as thoroughly and suitably provided for as this of Downs' was twenty-five years ago, as I have just described it."

In January, 1865, Downs read his first paper before the N. S. Institute of Natural Science, on the land-birds of Nova Scotia, which was the result of forty years' observation of bird life in this province. This subject he continued in a paper read in May of the following year.

In the latter part of 1867 he was proposed for superintendent of the Central Park menagerie, New York, being recommended by Prof. Spencer F. Baird, of the Smithsonian Institution. In the following year he disposed of his animals and grounds and went to New York; but being, it it said, displeased by what he considered an over-abrupt and apparently cool reception from one of the commissioners, he did not accept the appointment and returned to Halifax at the end of about three months.

Soon afterwards he purchased a new property (subsequently S. A. White's and Capt. W. H. Smith's) adjoining his old place, built a house and started a new zoological garden. This he continued to improve for about three years, gathering around him birds and other animals, and continuing his taxidermic work, in which he excelled.

Subsequently he lived for years on Agricola Street, surrounded by living animals and specimens, where his house was well-known to naturalists. A couple of years before his death, he, with the vigor which characterized him, although venerable in years, built a museum annex to his house and placed therein his extremely fine collection of mounted native birds. The writer remembers with pleasure many pleasant hours spent there in conversation with the aged and kindly naturalist, surrounded by hundreds of reminiscent specimens.

He died after a brief illness at Halifax, on 26th August, 1892, wanting but one month of eighty-one years.

He was twice married, first to Mary Elizabeth Matthews of Halifax, who died in 1858, having had four daughters, two of whom survive; and secondly to Matilda E. Muhlig of Halifax, by whom he had one daughter who survives.

Ornithology was his chief study, and the store of knowledge he possessed of our birds was very large and always freely at the service of enquirers. He took particular delight in encouraging the study of nature in young people. He was distinctly a field naturalist rather than a student of books.

His taxidermic work was very fine and was evidence of much loving, faithful labour. The preliminary operations were accomplished with skilful rapidity, but the final manipulations were done with great care. I have seen him sit in conversation for hours, with a recently mounted specimen beside him, from time to time adjusting feathers, often one at a time, or slightly altering the pose here or there, until all satisfied his critical eye. He had the rare ability of giving his specimens the appearance of having actual flesh within them. For his taxidermic work he received many awards at exhibitions in England and elsewhere, including a bronze medal at London in 1851 and in 1862, a bronze medal at Dublin, 1865, and a silver medal at Paris, 1867. Sir Wyville Thomson, in a critical article on the natural history section of the Paris exhibition, writes ("Illustrated London News," 24th August, 1867):—"In the Nova Scotia Court there is a very beautiful collection of birds stuffed by . . Mr. Downs. These birds are nearly perfect in their way; perhaps there is a little too much sameness in the attitudes, but the form and the proportions of the body are perfectly preserved, and there is scarcely a feather out of place."

Mr. Downs claimed he had stuffed about eight hundred moose-heads and supplied King Victor Emmanuel with many thousand dollars' worth of animals and specimens. At one time this sovereign had in his acclimatization garden at Pisa a number of living moose and caribou supplied by the Nova Scotian naturalist. Specimens of his taxidermic work were supplied other European sovereigns, and large quantities went to the great museums and private collections on both sides of the Atlantic, and a number are incorporatsd in the collection of the Provincial Museum at Halifax. His own private collection of some fourteen cases, which he had at the time of his death, is still the property of his estate.

He was one of those connected with the foundation of the Nova Scotian Institute of Natural Science, although he did not take up his membership until December, 1863. He was also a corresponding member of the Zoological Society of London, having been elected early in 1862.

He published, unfortunately, but little. His papers, all in the "Transactions of the N. S. Institute of Natural Science," were :

On the Land Birds of Nova Scotia. Vol. i, pt. 3 (1864-5), pp. 38-51 (read Jan. 9, 1865) ; vol. i, pt. 4 (1865-6), pp. 130-136 (read May 3, 1866).

[An annotated list, giving a total of 91 nominal species, being the result of "forty years' experiences in bird life."]

Pied, or Labrador, Duck. Vol. vi, (Trans. for 1885-6), pp. 326-327 (read May 10, 1886).

[Notes on two specimens in Dalhousie College Museum, Halifax, and other notes regarding the occurrence of the species in Nova Scotia, &c.]

A Catalogue of the Birds of Nova Scotia. Vol. vii, (Trans. for 1887-8), pp. 142-178.

[An annotated list, giving 240 nominal species, the result of "sixty-six years of practical field work." Prepared in summer of 1888. The note to the title, "read May 14, 1888," should be struck out.]

At a meeting of the Royal Society of Canada in May, 1888, he presented a paper "On the Birds and Mammals of Nova Scotia," which was not, however, published.

He was a man of very quiet and retiring disposition, disseminating his stores of knowledge mostly verbally or through a large correspon-

dence with the foremost naturalists of his day. He had a high sense of honour and was of a genial, kindly disposition, and was much respected by all who knew him. It has been truly said of him by his friend, Charles Hallock, that "his modesty was always such that his name is hardly known outside of scientific circles, while his credentials he folded away in a napkin." He remembered once seeing Audubon, with whom he also corresponded, and was a friend and great admirer of Charles Waterton, the naturalist, at whose house, Walton Hall, in England, he had been a guest, and whose "Wanderings in South America" he greatly admired and frequently quoted. He also corresponded with Frank Buckland and most of the foremost zoologists of his time.

Jan. 26, 1903.

THE KINGS COUNTY BRANCH OF THE NOVA SCOTIAN INSTITUTE OF SCIENCE: OUTLINE OF PURPOSES AND AIMS OF THE SOCIETY.—BY PROFESSOR ERNEST HAYCOCK, *Acadia College, Wolfville.*

The Kings County Branch of the Nova Scotian Institute of Science was organized on May 29th, 1901. The society was formed primarily to meet the needs of such Kings County members of the Institute of Science as were unable to attend the meetings of the parent society at Halifax, and who believed that much personal encouragement and stimulus was to be derived from the meetings of such a society. Furthermore it was believed that there were many others, young and old, who might be brought within the sphere of its influence, and that the scientific spirit would be stimulated and knowledge disseminated by such an organization.

The highest work in science is investigation of the unknown. By such investigation new facts are brought to light and added to the existing sum of knowledge, to be handed down as the heritage of succeeding generations. The marvellous attainments of the nineteenth century, and the civilization of the present, as compared with that of the earlier centuries of the Christian era, are due to such an inheritance, and it is the duty as well as the pleasure of the present generation to add its mite to this epitome of progress. The purpose of the parent society is to foster this investigating spirit in its members, and to add the results of their labors to the body of the world's literature. This will be the chief object of the branch society also, and we believe that the papers presented at its meetings will show a definite and real accomplishment.

As a rule the investigator needs considerable preliminary training, and a comprehensive knowledge of what is already known about his subject, in order to work to advantage, and achieve results that will be new to the world. The promoters of this society hope to provide this preparation, as far as lies in their power, and since it consists of two parts—1st, training in power of observation, and 2nd, the acquisition of facts already known—the work of the society will likewise consist of two parts, the presentation and discussion of the

results of original investigation by its members, and the presentation and discussion of papers on contemporary discoveries in science, or on scientific subjects pertinent to our especial needs. The former will suggest methods and point the way to exploration of the unknown; the latter will aid in furnishing the basis of knowledge necessary to fruitful investigation.

Although an arduous preparation is absolutely necessary for work of the above character in many branches of science, yet in many more departments of scientific study anyone with a love for truth and an honest interest in the world about him, whether he be young or old, whether he has or has not had a scientific training, may make contributions to the sum of human knowledge. These departments lie mainly within the domain of what are known as the Natural Sciences, and in them we hope to achieve our best results. The distinct aim of the society should be, in my judgment, to explore the natural history of Kings County, and in order to train workers for that purpose, to disseminate knowledge of the natural sciences in the widest possible way.

In designating this as the work of the society, we assign a field that lies all about us, that has scarcely been touched by the investigator, and in which the maximum results can be secured with the minimum amount of preparation. A few hours reading would put one in possession of all the facts that have as yet been recorded in regard to the geology of the county. A smaller number of hours would enable one to read the mineralogical record. I know of but one paper on the microscopic study of a Kings County rock, and this new science of petrography offers to one who is willing to make the necessary preparation, an outlook that is very fascinating. An admirable beginning in the zoology of the county has been made by Mr. Harold Tufts, who has published a list of 250 birds that occur within its borders. This list is without doubt still incomplete,, and further, every bird enumerated should be on exhibition either in a public county museum or in a private collection, in order that the correctness of the identifications might be verified at any time. Similar work in the land animals, the marine vertebrates and invertebrates, is waiting to be done, and the collection of all the known insects of the county and the study of their metamorphoses and habits, is a work not only of scientific interest, but likely to prove of untold value to the fruit growers

and agriculturists of the county. The botanical exploration of the county is still another equally attractive and important field for study. Since many of the diseases that injure the cultivated plants are lower forms of plant-life, investigation along this line is also likely to prove valuable from an economic standpoint. The geography of the county, its tidal phenomena, its meterology, are all subjects that will prove fruitful in result to the investigator. Our need will never be a lack of work but a lack of workers.

Advance along these lines can only be made by the slow and patient accumulation of material and facts, extending over years, but my hope is before long to see workers within the county in every department enumerated. Already beginnings have been made in several of them, and these beginnings are indicative of a real interest at present, and significant of great results in the future.

Thinking men are convinced that our progress, as a people and as a nation, is being and will be decided by the way in which we meet and settle the scientific question. If we foster the teaching of science in our schools, and the scientific spirit in our people, the adoption of scientific methods in the manifold industries of our country will follow as a natural consequence, and place us in the front ranks of the competing nations; but if we are content to go along in the systems of education and methods of industry followed by our fathers we must expect to take a rear place and see ourselves outstripped by peoples of a more progressive spirit.

I regard this fact, among others, that Kings County is the first in the province to form an affiliated society with the Nova Scotian Institute of Science at Halifax, the centre of the scientific life of the province, as an indication that this county is ready to accept the conditions of twentieth century progress, and proposes to take no second place among the county units in scientific and industrial achievement. Let us not measure our influence by our numbers, but grapple boldly with the difficulties that confront us, and strive to carry out the purpose for which we have united.

TRANSACTIONS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1898-99.

I.—Statistics of Expenditure and Consumption in Canada. —By Professor John Davidson, M. A., Phil. D., *Fredericton, N. B.*

(Read Nov. 14th, 1898.)

The ultimate test of a nation's prosperity is the quantity and quality of the goods it contains. Other tests are relative and indicate business activity rather than national welfare. All wealth is produced to be consumed, and the whole process of production is carried on for the benefit of the consumer. For him there is seedtime and harvest; for him the factories and the stores are run; for him railroad and steamship lines operate, and banks conduct their business. It is conceivable that the volume of business may be large within a nation which yet is poor and relatively unprosperous. Increased activity does not always mean increased welfare; and that community alone is rich and prosperous at whose command this activity places a large stock of consumable goods; and the most satisfactory evidence of this command is provided by the statistics of the consumption of the community. That is direct evidence; all other evidence is indirect and presumptive.

Unfortunately, direct evidence is not always available. We depend for information almost entirely upon government bureaus and departments; and these are concerned chiefly with their own

affairs. They collect figures of exports and imports because of the obvious bearing of such figures upon the collection of a revenue; and in some cases provide us with information regarding the industry carried on within the country because certain articles of manufacture are subject to internal revenue duties. Where there is no question of collecting revenue, the information afforded us is not usually carefully collected. We know more accurately what is imported than what is exported; we know better how much beer is consumed than we do how much meat or grain is consumed; how much tobacco better than how much clothing. The interest of the government is mainly in the collection of revenue. An enlightened government may make provision for the collection of other statistics; it may establish labor bureaus and agricultural departments; it may publish banking returns and railroad earnings; but since the interest of these things is not so immediately practical, the information afforded is apt to be meagre and to cease, short of the point of completeness. For instance, the main industry in Canada is agriculture; but we know less of the output of our farms than we do of the output of our breweries. Ontario and Manitoba collect elaborate agricultural statistics; but in the other provinces the gathering of information is perfunctorily performed or not performed at all; and, consequently, we cannot even use what information we have, because statistics of interprovincial trade are lacking. In the census years, elaborate returns are made; but even here there are gaps in our information, and too much of what is set down depends on the memory of the private citizen, which is not a scientific instrument. In Canada there is an additional difficulty in the way of obtaining adequate consumption statistics. Nearly half of our population is dependent on agriculture. In time, and with organization, we may learn the amount of eggs and potatoes, milk and meat and vegetables, maple sugar and cordwood marketed; but it will always be next to impossible to ascertain how much of these commodities the autonomous producer uses in his own consumption. Private investigation may step in to make up for the deficiencies of

governmental machinery; but until the community is so far educated that there is a statistical or economic association in every parish, we can hardly hope for the fullest information. Consumption is in its nature a private concern, and man will require to be much more methodical than he is at present before we can present anything like a picture of the consumption of a people. At the present time we are compelled to use what information we have as an indication of the complete result; and generalizing from the experience of individuals, treat the consumption of certain articles, for which the government provides statistics which may be relied upon, as representing the whole.

It is necessary first to shew in what proportions the people of Canada expend their incomes, because otherwise we should not be able to estimate the importance of the results obtainable for the consumption of specific articles. If the total expenditure of a people on food amounts to no more than fifty per cent. of its income, an increase in the consumption of coffee will mean a less increase of prosperity then it does for a people which spends seventy per cent. of its income on food. In the latter case it means that the people are rising from the lowest class, where the necessaries of life absorb the greatest part of the income, to a condition where other considerations are becoming important; in the former case it may mean a change in the form of consumption only. This aspect of the question has some immediate practical importance. In the discussion of the financial aspects of prohibition, little attention has been paid to the fact that not all the expenditure of the Canadian citizen is on taxable goods. Prohibitionists claim that the fifty million dollars annually spent upon intoxicants will necessarily be spent on other articles, and that the government need not confuse the issue by dark suggestions of direct taxation; for consumption will not be reduced, but simply changed. But, though the same amount will still be spent, it does not follow that it will be spent in such a way as will provide a reveuue. In so far as it is spent on food, there would be an increased consumption of food-stuffs on which, while the consumer may be paying a tax in the shape of enhanced prices,

due to protection, the government may realize little or no revenue; while in so far as it is spent on education or on better house accommodation, the government would gain nothing whatever to make up for the revenue from the taxes on beer and spirits. No doubt, there would be increased expenditure on clothing; but the percentage of income spent in Canada is but 17; and the tax is already as heavy as it can be to be productive of revenue. Probably seventy-five per cent. of the changed consumption would yield no revenue whatever.

The investigation of expenditures has been carried so far that certain empirical laws have been established. It may seem to some that the forms of expenditure are so much a matter of individual taste and caprice that no general conclusion can be established; but, after all, the differences among men are not very great. The fundamental necessities of life are the same for all, and caprice does not enter in till the dominant wants have been satisfied; and by taking a large number of instances, the effects of individual caprice may be eliminated and an average set down. The first fairly complete investigation in this sphere was made by Engel, and subsequent investigation has served to establish his conclusions more firmly.

These are:—That the greater the income, the smaller the relative percentage of outlay for subsistence;

That the percentage of outlay for clothing is approximately the same, whatever the income;

That the percentage of the outlay for rent and for fuel and light is invariably the same, whatever the income;

That as the income increases in amount, the percentage of outlay for sundries becomes greater.

We are fortunately able to present results for Canada, which may be compared with the statistical data brought forward by Engel and other investigators. The Ontario Bureau of Statistics during several years presented statistics on the expenditure of the working classes in certain cities of Ontario; and in countries

like Canada, where there are few extremes of wealth and poverty,* the results thus established may be accepted as tolerably accurate for the whole Dominion. Local variations there must, of course, always be. Rent is higher and fuel dearer in the towns than in the country; while in the country food probably, and clothing certainly, on the whole, are dearer than in the cities. The figures cover a period of four years, and their accuracy has been tested by the statistician and verified by comparisons. The statistics of five of the more important towns in Ontario have been selected by the writer for further analysis and calculation, and the results are set forth in the tables on the next page.

When these tables, which are extracted from the Bureau Reports, are reduced to percentages and expressed in terms of the number of day's labor necessary to command the various goods enumerated, we get the results in a form which permits comparison with other countries. The results in this form are contained in the tables on p. 7.

---

*Compare the sections of this paper dealing with house accommodation later for n enquiry into the existence of extremes of wealth in Canada.

	Earnings.	Day's labour in year.	Rent.	Fuel.	Clothing, per head.	Food, per head
			City of Hamilton.			
1886	$449	216	$76	$41	$16.45	$53.65
1887	415	234	81	41	12.89	45.76
1888	417	230	81	38	13.43	47.74
1889	418	244	90	37	13.89	38.65
Average.	424.7	231	....	....	....	....
			City of Kingston.			
1886	$469	293	$70	$36	$18.12	$43.90
1887	453	266	70	42	12.91	... .
1888	482	280	70	41	18 92	43.19
1889	379	244	68	31	22.28	49.63
Average.	446	271	....	....	....	....
			City of London.			
1886	$425	270	$73	$40	$17.66	$45.63
1887	421	265	70	40	15.58	50.39
1888	436	268	77	40	18.59	47.31
1889	431	244	66	37	15.91	46.54
Average.	428	261	....	....	....	....
			City of Ottawa.			
1886	$523	305	$ 81	$34	$21.96	$35.46
1887	385	223	97	32	10.52	36.55
1888	505	228	71	37	13.14	45.70
1889	440	255	110	33	11.94	35,15
Average.	463	253	....	....	....	....
			City of Toronto.			
1886	487	272	$ 92	$40	$23.96	$54.32
1887	480	246	112	41	16.93	47.92
1888	526	270	121	45	15.87	45.62
1889	474	262	110	39	16.67	56.89
Average.	492	263	....	....	....	....

	Days of Labor Necessary to Procure				Percentages of Income Expended on			
	Rent.	Fuel.	Clothing per Family.	Food.	Rent.	Fuel.	Clothing per Family.	Food.
Hamilton.								
1886	36	19	38	123	17	9	18	57
1887	45	23	35	124	19	9	15	50
1888	45	21	34	123	19	9	15	55
1889	52	22	37	103	21	9	15	42
Aver.	44.5	21.2	36	118.2	19	9	15.7	51
Kingston.								
1886	44	22	52	124	15	7	18	43
1887	41	25	35	....	15	9	15	....
1888	40	23	46	105	14	8	16	38
1889	45	20	58	127	18	8	24	52
Aver.	42.5	22.5	47.7	118.6	15.5	8	18.2	44.3
Ottawa.								
1886	47	19	64	123	15	6	20	40
1887	53	18	32	106	23	8	14	49
1888	32	16	34	124	14	8	15	53
1889	64	19	39	109	25	8	14	49
Aver.	49	18	42.2	115.5	19.2	7.5	15.7	47.7
London.								
1886	46	25	54	141	17	9	20	43
1887	41	25	43	141	16	9	16	50
1888	47	24	58	107	17	9	19	40
1889	37	20	44	130	15	8	18	53
Aver.	42.7	22.5	49.7	129.7	16.2	8.7	18.2	46.5
Toronto.								
1886	51	22	53	143	19	8	20	50
1887	51	21	36	107	23	8	17	43
1888	62	16	34	124	23	8	14	57
1889	61	21	37	93	23	8	14	49
Aver.	58	20	40	117	22	8	16.2	49.7

For purposes of comparison, however, the corresponding figures and percentages for the whole number of towns taken together, and for the whole province, are more useful; and suit our purpose of international comparison better:—

PROVINCE OF ONTARIO.

	Earnings.	Days of Labor.	Rent.	Fuel.	Clothing per Head.	Food per Head.
1886	$451	270	$76	$40	$20.83	$42.30
1887	449	257	82	39	15.85	44.37
1888	479	269	77	37	17.41	42.76
1889	467	272	81	41	17.10	44.14
Aver.	462	267	....	....	....	... .

	DAYS LABOR NECESSARY TO PROCURE				PERCENTAGES OF INCOME EXPENDED ON			
	Rent.	Fuel.	Clothing per Family.	Food per Family.	Rent.	Fuel.	Clothing per Family.	Food per Family.
1886	45	24	57	91	17	8	21	33
1887	45	22	41	91	18	8	16	35
1888	41	20	46	115	16	7.7	18	43
1889	47	23	46	122	17	8.8	17	44
Aver.	44.5	22.2	47.5	105	17	8.1	18	39

The average of the averages of the five cities above may be placed beside the provincial average (taken from returns made by artisans in the smaller towns and villages):—

	Earnings.	Days Labor in year.	PERCENTAGES EXPENDED ON			
			Rent	Fuel.	Clothing per Family.	Food per Family.
City average, 1886-89	$451	256	18.4	8.3	17	47.8
Prov. average, 1886-89	462	267	17	8.1	18	39.

The results thus obtained are in substantial agreement with the results established under greatly varying conditions in

Europe and America, as the following tabular comparison shews. The table is taken in part from Schönberg's Handbuch and in part from U. S. Labor Reports :—

Percentages on	Great Britain.	Prussia.	Ontario.	Massachusetts.	Illinois.
Food	51.36	50.00	39.0	49.28	41.38
Clothing....	18.12	18.00	18.0	15.94	21.00
Rent........	13.48	12.00	17	19.74	17.42
Fuel	3.50	5.00	8.1	4.30	5.63
Sundries. ..	13.54	15,00	18.9	10.73	14.57

These percentages are all calculated from working-class family budgets, except in the case of Prussia, where a family of intermediate class was taken to give gross incomes of something like the same amount. The real measure of well-being probably consists, at least for men of the same race, in the amount which may be expended on the vague class of sundries; and in this comparison, Canada comes out well. The shewing would not have been so favorable had we taken the average of the five cities, for then it would have been 8.5 per cent of the income only.

The question of the value of these returns is almost settled by the large degree of correspondence between independently reached results; but the Provincial Statistician, Mr. Blue, was at the trouble to meet the objection that, to say nothing of the conclusions based on them, the figures themselves were untrustworthy, by carefully examining the food expenditures of various public institutions. The force of the objection is that while most householders can tell how much they spend on rent and fuel, and perhaps also on clothing, they can make a rough estimate only of the household expenditure on food. Mr. Blue went into the matter exhaustively and examined the food accounts of colleges, asylums, military barracks, etc., and embodied his conclusions in a paper read before the American Public Health Association, and reprinted in the Ontario Bureau of Statistics Report, 1886, in which he says :—

"Now let us see how the cost of food, as computed from the working men's returns, compares with its cost in the schools and colleges and public institutions. At the average of summer and winter returns in these, it is $44.17 (,*per cap.*); at the prison's rate it is $35.51; at the asylum rate it is $47.12; at the infantry school rate it is $54.75; at the college winter rate it is $59. . . . . The working man's average, $47.67 *per cap.*, is therefore something more than a probable one; it is well verified by statistics gathered from other sources, and I am disposed to think that the cost of living is better known and more accurately gauged in the families of the working classes than in the families of any other class in the community." . . . .

We are justified, therefore, in accepting the average budget based on these returns as representative of the actual expenditure of some hundreds of working men throughout Ontario. It is true, no doubt, that men capable of intelligently making such returns are likely to spend their incomes more rationally than others of their class; but the extravagances and waste of the less prudent and thrifty in part offset each other, and must for the rest be neglected. We may assume, therefore, that in the Province of Ontario 39.0 per cent. is expended on food, 18.0 per cent. on clothing, 8.1 per cent. on fuel, and 17 per cent. on rent; or if we take the average of the 4 year averages of the five important towns as our standard, 47.8 per cent. on food, 17 per cent. on clothing, 18.4 per cent. on rent, and 8.3 per cent. on fuel.

These percentages are not without meaning even as an indication of absolute well-being. The smaller the percentage expended on food and subsistence the larger the total provision for the wants of our nature. Here and there an individual may be found who stints himself of the imperious necessities of life to obtain some coveted comfort or luxury; but the great majority satisfy the lower wants first and rise to the higher if sufficient provision is made. Consequently, the smaller percentage in Canada expended on food is an indication of a higher well-being. But it is necessary to investigate still further to find the degree of well-being and to present quantities rather than percentages.

What value does the average Canadian receive in food, house accommodation, fuel and clothing for the percentages of income thus expended? This is not a question of prices, but of weights and measures. Prices are of importance only as they indicate whether an increased or decreased consumption of any article is due to a change in price or to an increased command over the goods of life. The increased consumption of tea and sugar, for instance, is due to the fall in price; but the increased consumption of coffee, in so far as it is not simply a transfer of taste from one article to another, shows an extending margin of consumption. An increase of consumption due to a fall in the price of an article does not necessarily mean that the citizens are better off. Their real wages and incomes have risen but their money wages may be constant; but an increased use of an article whose price has not fallen indicates an increase of money wages and a more extended command over the goods of life.

It is not possible, unfortunately, to enter into a detailed examination of the absolute values received in each class of expenditure. In the case of rent and food, we are able to present some of the more important items; but fuel and clothing remain indefinite.

The item of fuel is the only one which takes a higher percentage in Canada than in any other country. The cause is not an enhanced price, but the fact that a larger quantity must be used. The amount of fuel consumed per head of the population is unascertainable. From the mining statistics and the tables of trade and commerce, we can estimate how much coal, bituminous and anthracite, is used; but how many of the people of Canada use coal? Probably the majority of the population do not use it in any form; even in industry coal is not always used; and it is in the larger cities only that coal is used exclusively. The quantity of wood consumed as fuel is not ascertainable; and since the quantity varies according to the house and according to the habits of the individual, no estimates, even approximately correct, can be made.

Whether, under the head of fuel, lighting is also included, as it usually is in the statistics of other countries, is not stated; but the omission is not of serious importance, because we are unable to discover how much the individual spends and what value he receives for his expenditure. The three chief illuminants, gas, electricity, and oil, are being used in increasing quantities. The Census Reports of 1891 give figures for the production of gas and electric lighting works; but there has been a very great extension in the use of electric lighting since 1891, and possibly some increase in the use of gas also; and figures taken from the Census Reports would give a wrong impression. It is interesting to note that in spite of the increase in the use of these methods of lighting, the consumption of petroleum is increasing steadily year by year. The urban population of Canada (those residing in towns and villages of more than 1,500 inhabitants) has increased from 912 934 in 1881 to 1,390,910 in 1891; or from 21.1 per cent. to 28.77 per cent. of the population of the Dominion; and the number of towns of more than 3,000 inhabitants which may be taken as the minimum for which gas or electric lighting is provided, has increased from 68 to 94. Gas lighting held its own during the decade 1881-1891, and electric lighting was practically introduced in the decade (in 1881 there were two men employed in electric lighting works; in 1891 there were 1,190;) yet the consumption of petroleum increased *per capita* more than fifty per cent., although there was no corresponding decrease in the retail price. In 1882 the consumption was 2.0 galls. per head, in 1891 it was 3.2 galls., and in 1896 3.1 galls. (a decrease from 3.5 galls. in 1894 and 1895). The increased use of the more primitive illuminant, alongside of the development of the more modern methods, shews a real increase in well-being in the community.

The expenditure on clothing must remain in the obscurity of percentages. It might be possible, by help of the Census Reports and the trade tables, to determine how much cloth and clothing was manufactured or imported in the year 1891; but it is not possible to shew how much was consumed. Trade tables

are trustworthy only when they extend over a number of years, and speculative influences can be discounted. An alteration in the tariff, for instance, may affect the imports for a given year, as it did in the case of sugar, and strictly an average of several years ought to be taken. The census year is no more likely to escape such fluctuations than any other year; and it might be seriously misleading to take the manufacture and importation of textiles as typical. Moreover, there has not as yet been established in the matter of clothing any standard of consumption as has, in a measure, been done in the case of food. Caprice and local climatic causes have here an undue influence. All we can say is that in Canada the average family spends on the average \$83.79 on clothing, the family expenditure in the United States being \$112.23; in Great Britain, \$80.59; in Germany, \$57.21; in France, \$72 60; in Belgium, \$84.61; in Switzerland, \$65.38*.

The statistics available for the further analysis of the expenditure on rent are not sufficient for the purposes of comparison either of classes or of different periods. With the exception of some interesting sociological studies of a portion of the city of Montreal by Ald. Ames of that city,† we have the Census Reports alone to rely on; and the Census Reports of 1881 offer but a very meagre amount of information. The Ontario tables quoted above shew that on the average in the province of Ontario the respectable working classes spend 17% of their income in rent. Since there is comparatively little class distinction in Canada, we might, perhaps, assume that 17% represents the proportion spent by the average Canadian on house rent. In the city below the hill in Montreal rental absorbs, according to Mr. Ames, 18% of the earnings:—"For families of the real industrial class 16 per cent. is a fair average. . . It is among the well-to-do and the very poor that rental is permitted to absorb from 20 to 25 per cent. of the earnings." (The City Below the Hill, p. 40). Mr.

*U. S. Commissioner of Labor, Report 1891, Vol. II., pp. 864-5.

†(1) The City Below the H.ll: privately printed. (2) Incomes, Wages and Rents in Montreal (U. S. Department of Labor, Bulletin 14, Jan. 1848); and a lecture on House Accommodation which I have been privileged to see in manuscript.

Ames, in a letter in answer to some queries made, has further explained that the last sentence refers only to families with an annual income of $1000 or less. "My experience, he adds, has gone to prove that rental consumes from one-fifth to one-third of the income of the very poor. Then the proportion grows gradually less as we reach the classes where the family income runs from $8.00 to $12.00 per week. Those families receiving from $12.00 to $15.00 seem to pay a smaller proportion of income as rent, but classes receiving from $15.00 to $20.00 seem to grow ambitious and desire to move into larger quarters. I am of the opinion, although I have no facts to substantiate it, that if we were to take classes receiving annually $1000 a year and over, we would find the rental proportionately diminishing the higher we go" Thus, Mr. Ames's results hardly bear out Engel's law, that the percentage expended on rent is invarirbly the same whatever the income; and it appears necessary to modify the law, at least, if we admit subdivisions of the working classes. The proportion is highest for the very poor, varying from 25 to 30 per cent.; for the 'real industrial' classes it falls to 16 per cent.; and then rises to 25 per cent. for highly skilled mechanics, and then gradually falls for families whose income exceeds one thousand dollars.

Before we go on to enquire what sort of accommodation is obtained for this expenditure of income. it is necessary to verify the assumption made in last paragraph that there is comparatively little distinction of classes in Canada. In a sense this is an obvious fact, a matter of ordinary remark by every observer. While there are few in Canada who are very wealthy, there are probably as few who are in actual distress. The Census Report, 1891, enables us to verify to a certain extent this common observation. For each census district we have given, in a series of tables, the number of houses and the number of rooms in each house. It would be obviously impossible, having regard to the limits of time and space, to analyze the returns for the whole Dominion; and since in the country districts there is little difference of class, it is necessary only to examine the returns for the

larger towns. In the large towns, if anywhere, we shall find distinctions of class appearing. The first of the following tables is taken directly from the Census Reports; the second is based on it and expresses the same facts in terms of percentages which have been calculated:—

CITY.	Population.*	Total No of Houses.	No. of Houses with Rooms—							
			1	2	3	4	5	6—10	11—15	Over 15.
Vancouver	13709	2231	140	148	194	331	223	1023	81	81
Winnipeg.	25639	4543	34	296	367	702	594	2309	162	79
St. John .	40385	6630	1	135	467	723	740	2996	1012	339
Halifax....	38495	5181	3	63	126	447	523	3351	529	108
Toronto ..	144023	25810	30	184	752	2480	3094	17070	1749	451
London ..	22281	4317	6	54	128	434	775	2603	223	80
Kingston .	19263	4725	37	148	445	700	708	2397	240	50
Hamilton..	47245	9221	8	72	279	870	1779	5596	488	109
Montreal..	182695	31931	153	1990	4672	7815	3325	10782	2542	651
Quebec	63090	8313	43	479	827	1508	791	3373	954	440
Ottawa ...	37269	6557	17	150	246	911	1025	3485	583	140

* The populations are taken from Table II, Vol. 1, Census Report, 1891.

CITY.	Persons to a House.	Percentage of Total Number of Houses with Rooms									
		1	2	3	4	5	6—10	11—15	Over 15.	4 and less.	10 and more.
Vancouver	6.1	6.2	6.6	8.7	14.8	10.0	45.8	1.6	1.6	36.3	3.2
Winnipeg.	5.6	0.7	6.5	8.0	15.4	13.0	50.8	3.5	1.7	30.6	5.2
St. John...	6.0	0.0	2.0	7.0	10.9	11.1	45.1	15.2	5.1	19.9	20.3
Halifax ...	7.4	0.1	1.2	2.4	8.6	10.0	64.6	10.2	2.1	12.2	12.3
Toronto...	5.5	0.1	0.6	2.9	9.6	11.9	66.1	6.7	1.7	13.2	8.4
London . .	5.1	0.1	1.2	2.9	10.0	17.9	60.2	5.1	1.8	14.2	6.9
Kingston .	4.0	0.7	1.1	3.1	16.4	16.4	50.7	5.0	1.2	22.3	6.2
Hamilton..	5.1	0.0	0.7	3.0	9.4	19.2	61.7	5.2	1.0	13.1	6.2
Montreal .	5.7	0.4	6.2	14.6	24.4	10.4	33.7	8.0	2.0	45.6	10.0
Quebec ...	7.5	0.5	5.7	9.9	18.1	9.5	40.5	11.4	5.2	34.2	16.6
Ottawa ...	5.6	0.2	2.2	3.7	13.8	15.6	53.1	8.8	2.1	19.9	10.9

With the exception of four cities, Vancouver, Montreal, Quebec and St. John, more than half of the population live in houses containing from 6 to 10 rooms; in the case of Toronto the percentage rises to 66 per cent; while in three others, Halifax, London and Hamilton, the percentage exceeds 60. Those cities

which shew a low percentage of houses containing 6 to 10 rooms per house (which gives something more than the standard accommodation of one room one person) shew generally a high percentage of houses of four rooms or less, and also of houses of more than 10 rooms. Thus, in Montreal, 45.6 of the houses are of 4 rooms and less; Quebec, St. John, Vancouver, Winnipeg and Ottawa, also give high percentages of houses of rather less than the standard accommodation; and with the exception of Vancouver and Winnipeg, where the poor accommodation is, as we shall see, due to the newness of the cities, the same towns shew a high percentage of large houses of more than ten rooms. Montreal has a percentage of 10.0; Quebec, 16.6; Ottawa, 10.9; and St. John, the astonishing percentage of 20.3. Halifax is the only other city where the percentage of large houses reaches double figures. If we combine the results of the last table and recognize three classes of houses only, those of 4 rooms or less, those of 5 to 10 rooms, and those with more than ten, we shall see at a glance where the conditions are extreme and where the arithmetical average expresses the truth of the situation :—

	4 rooms or less.	5 to 10 rooms.	More than 10 rooms.
Vancouver..........	36.3	55.8	3.2
Winnipeg	30.6	63.8	5.2
St. John.....	19.9	56.2	20.3
Halifax	12.2	64.6	12.3
Toronto	13.2	78.0	8.4
London	14.2	78.1	6.9
Kingston	22.3	67.1	6.2
Hamilton	13.1	80.9	6.2
Montreal......... .	45.6	44.1	10.0
Quebec	34.2	50.0	16.6
Ottawa......	19.9	68.7	10.9

It appears, therefore, that class distinctions are marked in three or four towns only: in St. John, Montreal, and Quebec, and possibly in Ottawa; that the three best housed towns where there are few extremes of wealth and poverty, are Toronto, London and Hamilton—which, with Kingston and Ottawa,

where also the conditions do not show violent extremes, are the five towns selected from the Ontario Bureau of Statistics Reports for detailed analysis. It is probable that the very large percentage of large houses in St. John is an indication, not of a large wealthy class, but of lack of prudence and foresight in the inhabitants in the years which followed the great fire. We might therefore conclude that in two towns only, Quebec and Montreal, do the extremes of wealth and poverty show themselves; and that the average condition is also the condition of the great majority of the inhabitants of Canada. We might, perhaps, also conclude that the average income obtained from the returns made to the Ontario Bureau is not far below the average income in Canada. Mr. Ames shows that in the district he has investigated there is a weekly average income of $10.20 per family, an average monthly rental of $8.73 per family, or 18 per cent. of the family income, and an accommodation of 5.02 rooms per family (U. S. Bulletin of Labor, p. 44. The average weekly income of the towns in Ontario is nearly $9.00, of which 17 per cent. is expended on rent in places where rents must be much lower than they are in industrial districts of Montreal, and where accordingly better accommodation will be given for the money. We may readily infer that the returns have been made by the occupants of houses of 7 or 8 rooms; and an overwhelming proportion of the inhabitants of the towns, of which an analysis of the house accommodation has been made above, occupy houses containing from 5 to 10 rooms. Since, according to Engel, and according also to the best canons of local taxation, the expenditure on house rent is the best indication of income, we might be safe in concluding that the average income set down above is the average for Canada; but at the best the conclusion is problematic and based on a series of assumptions and inferences from data which are themselves only approximately correct.

The main qnestion is the actual accommodation obtained for

the expenditure. The best test, perhaps, would be the cubic feet of air space obtained for a given rent.*

But statistics are lacking in Canada to determine the actual space received in return for the payment made. There may be more actual air space in a log cabin or a dug out of one room in the North-West and British Columbia than in a three or four roomed house in a back tenement in Montreal; and the general sanitary conditions are without doubt superior. Mr. Ames has taken the provision of water closets as his test, and shews how a smaller house with sanitary conveniences may rent for as much as a larger without them. But his investigation was confined to a section of Montreal only. For the rest of the city, and for the Dominion as a whole, we must rest content with a less satisfactory test, viz., the number of rooms, the material of construction, the number of stories, the number of families in each house, and the number of persons to a house and to a room.

The average house in Canada is constructed of wood, is of one story, or a story and a half, contains probably from 5 to 10 rooms, more likely 5 than 10, and accommodates under its roof 1.08 families, or 5.6 persons, and thus gives the standard accommodation—one room one person. The standard of accommodation is rising. In 1881 there were 1.10 families under each roof and 5.8 persons. The one story house seems to be going out of fashion, for while 39 per cent. of all the inhabited houses are one story buildings, more than 50 per cent. (23,227 out of 46,000 classified) of the uninhabited houses are of one story only, and 33 per cent. only (2,704 out of 8,077 enumerated) of the houses under construction. (Census Bulletin, No. 6). It is, moreover, a well recognized fact that the sanitary conveniences are being improved. So that we may conclude that the people of Canada are receiving better value for their money, or that through increased prosperity they are able to spend a larger absolute amount in house rent though, perhaps, the percentage of their expenditure on house rent is decreasing.

*The poor probably pay more for rent, according to this standard, than the rich It has been found by comparison in Vienna that in a house in one of the slum districts each cubic metre of air space cost 3 fl. 24 kr., while in a house in the most fashionable Ringstrasse, and on the first floor, the cubic metre cost 2 fl. 85 kr. only. (Schönberg's Handbuch, I., p. 700.)

Wooden houses constitute 81.6 per cent. of the total number; brick houses 15.34, and stone houses 3.1. The brick and stone houses are probably mainly in the larger cities and occupied by the wealthier classes. Thirty-nine per cent. of the total houses inhabited are of one story, while 43 per cent. of the wooden houses are of that humble size, and 19 per cent. and 20 per cent. only of the brick and stone houses fail to reach the dignity of a second story or even of an additional half story. The story and a half and two story buildings are 57 per cent. of the whole, but 60 per cent. of the stone and 67 per cent. of the brick houses are of these dimensions. Of the houses which have three stories or more 14,211, or 59 per cent., are brick, 4,658, or 19 per cent. are stone, and 5,746 only, or 22 per cent., are of wood.

The Census Reports do not enable us to discover whether there is a larger number of rooms or of stories in a stone or brick house then in a wooden house. Probably, the advantage in size is in favor of the stone and brick houses; but there is no definite information on the subject, and we must rest content with the statement given in the Census Report, 1891 (Vol. IV., Table A., pp. 378, 379) of the percentage of houses of different sizes in the several provinces of the Dominion:—

	Percentages of Houses with Rooms—								Of Houses with Stories—			
	1	2	3	4	5	6-10	11-15	Over 15.	1		3	4
Canada........	2.9	8.0	11.0	15.8	12.2	43.3	5.6	1.2	63.5	33.6	2.5	0.4
Br. Columbia..	21.1	13.6	10.2	13.5	11.4	25.9	2.6	1.6	72.4	26.3	1.2	0.1
Manitoba......	12.0	20.2	17.3	17.0	10.1	21.4	1.3	0.6	56.9	42.1	0.8	0.2
N. Brunswick..	2.4	8.7	9.8	14.4	11.6	43.2	8.2	1.7	79.9	16.7	3.0	0.4
Nova Scotia....	1.0	5.4	8.4	15.4	12.9	50.2	5.8	0.9	85.7	12 7	1.5	0.1
Ontario........	1.2	5.1	7.9	13.3	12.7	52.3	6.3	1.2	52.4	45.1	2.4	0.1
P. E. Island...	0.9	7.3	9.7	16.4	12.8	45.7	6.5	1.7	80.8	17.7	1.4	0.1
Quebec........	3.7	10.9	16.2	20.2	11.7	31.2	4.7	1.3	69.8	25.9	3.4	0.9
The Territories.	19.5	24.3	16.7	13.3	8.1	14.1	1.3	0.7	66.9	30.5	0.5	0.1

The house accommodation afforded varies from province to province. The largest percentage of brick houses occurs in Ontario, the smallest in Nova Scotia, where 99.4 of the houses are built of wood. The largest percentage, though not the

greatest absolute number of stone houses, are found in the province of Quebec, the smallest, 0.1 per cent., in British Columbia, New Brunswick, and Prince Edward Island. The proportion of houses of one story only is greatest in the Maritime Provinces, where Nova Scotia heads the list with 85.7 per cent., and Prince Edward Island and New Brunswick follow with 80.8 per cent. and 79.9 per cent. Manitoba and Ontario show the largest percentages of two story houses, while Quebec and New Brunswick show the highest percentages of three storied dwellings. Quebec contains 73 per cent. of all the 4-storied buildings in Canada; and twice as high a percentage of the buildings in the province are of that height or higher as in any other province. Quebec and the North-West Territories have highest average number of persons under one roof (6.0), the Maritime Provinces coming next, and British Columbia giving the low number of 4.9. But British Columbia is the province where the largest number of one-roomed houses exist. Twenty-one per cent. of the houses there have one room only, and 58.4 per cent. have four rooms or less. In Manitoba, which stands next to British Columbia in the number of persons to the house (5.2), 12.0 per cent. of the houses are one roomed, and 66.5 per cent. have four or less. Prince Edward Island, on the other hand, which crowds 5.9 people under every roof, sees that they have some room under it, for less than one per cent. (0.9) of her houses are of one room, and 65.3 of her houses have more than four rooms.

These facts are collected in the following table:—

COMPARISON OF HOUSE ACCOMMODATION IN THE PROVINCES.

	Stone Houses.	Brick Houses.	Wooden Houses.	One room.	4 rooms or less.	Persons under one roof.
Canada	3.0	15.4	81.5	2.9	37.7	5.6
British Columbia..	0.1	2.3	97.6	21.1	58.4	4.9
Manitoba	0.9	3.7	95.2	12.0	66.5	5.2
New Brunswick...	0.1	1.6	98.2	2.4	35.3	5.8
Nova Scotia	0.2	0.3	99.4	1.0	32.2	5.7
Ontario	3.3	21.1	75.5	1.2	27.5	5.2
Pr. Edward Island	0.1	0.4	99.5	0.9	34.7	5.9
Quebec............	5.0	17.8	77.1	3.7	50.0	6.0
The Territories....	1.0	1.0	96.0	19.5	73.8	6.0

From these figures it is possible to construct an index number which shall express the relative house accommodation of the various provinces more readily than the actual figures. There are four possible tests within our reach :—The material of which the dwelling is constructed, the number of rooms it contains, the number of stories in it, and the number of people who inhabit it. But these are obviously not all ot equal importance. The number of rooms is of much greater importance than the number of stories. A house of five rooms with only one story is better than a house of three or four rooms with a story and a half or two stories; and for many purposes it is indifferent whether the house is built of wood or of stone, or brick. The material out of which a house is built is determined sometimes by the relative cheapness of materials on the spot and sometimes by municipal regulations about a fire district. But from the figures quoted above, it is evident that a stone or brick house is at least more fashionable than a wooden house ; and in the slum districts of our cities the worst houses are built of wood. We must allow some importance to these two considerations; but not by any means as much as to the others. If to the two taken together we allow half as much importance as to each of the others, taken separately, we will not, perhaps, exaggerate its importance ; but in case of error, the index number will be stated, both including and excluding these minor considerations. The figures quoted above are taken negatively, *i. e.*, instead of saying how many houses have four rooms or less, we calculate on the number of houses which have more than four rooms; but this is a matter of arithmetical detail. The average for Canada is expressed as 100 in the cases of the number of houses containing more than four rooms and of the number of persons in each house, and by 50 in the case of the two minor considerations :—

	% of houses with more than four rooms.	Index No.	%of persons to house.	Index No.	% of houses of more than one story.	% of houses of material other than wood.	Index No.
Canada	62.3	100	5.6	100	36.5	18.5	50
Brit. Columbia	41.6	66.7	4.9	114.6	27.6	2.4	19.6
Manitoba	33.5	53 7	5.2	107.6	40.1	4.8	33.7
N. Brunswick.	64.7	102.2	5.8	96.4	20.1	1.8	16.1
Nova Scotia ..	67.8	107.2	5.7	98.4	14.3	0.6	10.6
Ontario	72.5	116.3	5 2	107.6	47.6	24.5	65.7
P. E. Island ..	65.3	104.8	5.9	94.9	19.2	0.5	13.8
Quebec	50.0	80.2	6.0	93.3	30.2	22.9	51.2
Territories....	26.2	42.0	6.0	93.3	33.1	4.0	28.1

The index of relative house accommodation of the provinces would be therefore according as we did or did not include the minor considerations expressed in the first or in the second column below :—

	Two Considerations.	Four Considerations.
Canada	200	250
British Columbia	181.3	199.9
Manitoba	161.3	195.0
New Brunswick........	198.6	214.7
Nova Scotin...........	205.6	216.2
Ontario	223.9	289.6
Prince Edward Island..	199.7	213.5
Quebec	173.5	224.7
Territories	135.3	163.4

The inclusion of the minor considerations reduces the rank of all the Maritime Provinces, and raises Quebec from one of the lowest to the second place, and still further increases the lead of the Province of Ontario. In all probability the index number depending on the two considerations alone gives the fairest representation of relative housing in the various provinces.

Though the item of food continues, whatever the income, to absorb the largest share of individual and national income, our information on this point is far from being complete. Practically we may say that so far as the foodstuffs consumed in Canada are produced in Canada we have no adequate information. Esti-

mates have been made of the consumption of wheat and potatoes; but too much reliance should not be placed upon them. The consumption of meat might be approximately estimated after an elaborate calculation, taking into account exports and imports and annual mortality among farm stock; but to give the estimate even a semblance of accuracy we require to have at least as complete an enumeration of the stock in the country during successive years as we have for the isolated census years. Of the consumption of fish and game, of butter and eggs, and milk and cheese and vegetables, we have no means whatever of forming an estimate; and it is doubtful whether such an estimate can be formed so long as 45 per cent. of the population are engaged in, or dependent on, agriculture. The only accurate statistics we have of the consumption of food are those relating to articles not produced in Canada at all, or produced under such conditions that the whole industry is under the constant supervision of the government. We can tell how much tea and sugar and coffee, how much beer and spirits and tobacco, how much wine and dried fruit is consumed in Canada; and it is fortunate that these are the articles, the large consumption of which indicates prosperity. We are not concerned with the ethical question whether the consumption of spirits is right or wrong. As a matter of fact, and many a Finance Minister has had to confess it with chastened sorrow, an increased consumption of intoxicants is a sign of increasing prosperity.

Bread stuffs and meats are for English speaking people necessities, and a diminution in the quantity would indicate, or at least might indicate, increasing prosperity. The poorer a nation or a family is the larger the proportion of its income it spends on bread and potatoes.* This is one of the established

*Prof. Lexis, in his article on Consumption, Schönberg's Handbuch I., 697 *n.* quotes the following estimate of the distribution of expenditure on food by various classes:—

Expenditure on Food.	*Bread.*	*Potatoes.*	*Meat.*
(6 persons) 2,175 marks	14.9	4.1	26.5
4 persons) 1,285 "	10.6	2.4	29 0
688 "	31.3	4.8	17.0
403 "	38.7	10.3	11.6
395 "	39.4	15.9	3.5

conclusions of the theory of consumption; and it stands to reason that the more of the luxuries of the table a family consumes the less need has it for the grosser necessaries. But this conclusion must be taken to apply to percentages rather than to absolute amounts; for where the great majority of the population are in the condition of working class people, prosperity may show itself both in a decreasing percentage and in an increasing absolute amount. With a better use of the consumption power at their command, probably the working classes in America would come to consume less of the grosser necessaries of bread and potatoes and meat, and rise to a higher conception of well-being than mere profusion. The large consumption of bread stuffs in the exporting countries is due to profusion rather than to a low standard of living. It exists alongside of a large consumption of the comforts and commoner luxuries of the table.

Speaking in general terms, Europeans eat more bread and potatoes than Americans. Australians consume more meat and less bread and potatoes than either the Americans or the Europeans. In Canada the consumption both of bread and potatoes is, according to statistics, high, probably much too high, considering the standard of living common in the community. In the Statistical Year Book for 1891 the average consumption, calculated by deducting the net exports and the estimated amount retained for seed from the estimated crop during the 10 years, 1881-1891, is given as 6.75 bushels per head:—

CONSUMPTION PER HEAD, IN BUSHELS.

1881	6.48	1884	8.96	1888	6.02
1882	8.19	1885	7.41	1889	5.38
1883	6.16	1886	5.70	1890	6.60
		1887	6.63		

But the authors of this estimate do not themselves place much reliance on it; and if it were accurate, one would almost be justified in inferring that in the lean years Canada was on

the verge of starvation ; for the consumption varies more than three bushels and a half. The probability is, as the authors suggest, that the crop estimates are by no means accurate. In the following year, in 1892, this estimate is dropped, and a comparative estimate of the consumption of wheat per head in various countries gives Canada an average consumption of 5.5 bushels per head, which is continued down till 1895, the last year in which this comparative estimate appears. The estimate continues to be put forward as an approximation only ; but no reason is offered for the reduction from 6.75 to 5.5 bushels.

The consumption of potatoes may be estimated in the same way for the single year 1891, the census year. This gives an average consumption of 10 bushels per head, or about 600 pounds —undoubtedly, by comparison with other nations which have a similar or a lower standard of living, an excessive estimate. If the estimates framed annually by the Statistical Bureaus of Ontario and Manitoba are scarcely trustworthy, the casual estimates of a census enumerator, or of the farmer he questions, are still less likely to be trustworthy ; and all such estimates are liable to err on the side of excess.

Mr. Mulhall gives the annual consumption of meat in Canada at 90 lbs. per head, as compared with 109 lbs. in the United Kingdom, 150 lbs. in the United States, and 276 lbs. in Australia ; but imagination fails to suggest the source from which such an estimate can be made for Canada.

The statistics at our disposal regarding the consumption of certain typical comforts and luxuries, is as full as occasion requires, and as accurate as returns made at the customs or to the internal revenue officers usually are. The list might be made indefinitely long, but we confine ourselves to such as are typical and in fairly common use,—sugar and tea and coffee, wine and beer, and spirits and tobacco. Dried fruit we shall also include, selecting that rather than green fruit, the extension in the use of which is one of the best signs of a prosperous consumption, because, in the case of green fruits, we have estimates of value only which can be used, while the quantity of dried fruits can

be more readily estimated in a single one of the tables of weights and measures. The tables from which the per capita consumption of sugar, tea, coffee and dried fruit has been calculated, were compiled from the Annual Sessional Papers on Trade and Commerce; the per capita consumption of beer, spirits, etc., is the calculation of the inland revenue officials, and may be found in Statistical Year Book for the current year.*

The consumption of these articles is recognized as one of the best tests of the prosperity of a country. The middle classes everywhere are well provided with the comforts and decencies of life, in which class these articles are placed, although sugar is rapidly becoming a necessary of life; and an extension of the consumption of these goods means that the working classes are consuming more, the middle class, it being presumed already, using as much as they desire. In a country like Canada, where as we have seen there are few extremes of wealth, an increased consumption means that the whole body of the people are consuming more.

An increased consumption of any article may mean one of three things,—(1) it may result from a fall in price, which enables the people to consume more without spending more; (2) it may mean a rise in the average income, which enables the people to spend more on one article than they have been doing, without curtailing their consumption of other articles; (3) it may mean simply that the form of consumption has changed and that the well-being of society is the same, or but slightly increased. In all probability, the increased use of cocoa, from the value of $44,249 in 1880† to $158,849 in 1896 has been due to a mere change in the form of consumption; and the addition of this amount to the consumption of the community probably does not indicate a corresponding increase of spending power. The increase in the use of sugar and tea is due, not to increased

---

*I take this opportunity of acknowledging my indebtedness to the Dominion Statistician, Mr. George Johnson, whose work I have freely used in the preparation of this paper.

†Average of three years.

spending power, but almost entirely to a fall in price. The per capita cousumption of 1896, 47 lbs. of sugar and 4.4 lbs. of tea, cost no more than the 26 lbs. of sugar and the 2.7 lbs. of tea in the year 1880. The increased use of tobacco, of coffee, and the but slightly decreased consumption of spirits, in spite of a large rise in price, indicate a larger spending power. An attempt has been made in the third of the following tables to indicate how far the increased consumption is due to a fall in prices, the prices being taken from a table of Montreal prices given in the Statistical Year Book of 1896.

CONSUMPTION PER CAPITA OF CERTAIN ARTICLES IN CANADA.

	Tea (lbs.)	Coffee (lbs.)	Sugar (lbs,)	Dried Fruits (lbs).	Beer (gals.)	Spirits (gals)	Wine (gals.)	Tobacco (lbs)-	Cigars (No)
1880	2.7	0.40	26	1.9	2.25	0 71	0.08	1.94	.....
1881	3.8	0.47	31	3.0	2.29	0.92	0.10	2.03	......
1882	4.3	0.71	30	3.4	2 75	1.01	0.12	2 15	......
1883	4.0	0.60	34	5.0	2.88	1.09	0.13	2.28	......
1884	3 8	0.53	38	5.2	2.92	1.00	0 12	2 48	19
1885	4.0	0 94	43	4.1	2.64	1 13	0.11	2.62	17
1886	4.9	0.85	38	3.6	2.84	0 71	0 11	2 05	20
1887	3 8	0.41	43	4.2	3.08	0.75	0 09	2.06	18
1888	3 7	0.60	43	4.5	3.25	0.64	0.09	2.09	19
1889	3 6	0.66	47	4.6	3.26	0 78	0.10	2 15	19
1890	3.8	0.66	35	4.7	3.36	0.88	0.10	2 14	20
1891	3.7	0.69	40	4.8	3 79	0.74	0.11	2 29	20
1892	4.4	0.73	68	4.7	3.52	0.70	0.10	2.29	21
1893	3 6	0.77	51	4.4	3.48	0 74	0.09	2.31	23
1894	4.1	0 70	61	5.3	3.72	0.74	0 09	2.26	23
1895	4.0	0.72	70	5.2	3.47	0.67	0.09	2.16	21
1896	4.4	0.70	47	5.6	3.53	0 62	0.07	2.12	21

These tables are sufficiently clear to explain themselves ; but it should be observed that for some reason the year 1880, which has been chosen as starting point, is an exceptional year of low consumption, as we shall see more clearly when we come to present an Index No. of consumption ; and it has the additional disadvantage of being the year of high prices in sugar, which was then 20 per cent. higher than in 1875, and higher than it has been since.

It would be interesting to compare the consumption of the different provinces; but there are no statistics available for such a comparison. Mr. Johnson, in his *Graphic Statistics of Canada* (1886) has shewn the relative provincial consumption of wine and beer, and spirits and tobacco, in a graphic form; and from his representation we learn that on the average of 19 years to 1886, each inhabitant of Ontario drank 1.11 gals. of spirits, 0.4 gals. of wine, and 3.2 gals. of beer, and smoked 1.8 lbs. of tobacco; and so on for the other provinces as in the accompanying table:—

PER CAPITA CONSUMPTION ACCORDING TO PROVINCES.

Prov.	Spirits (gal.)	Beer (gal.)	Wine (gal)	Tobacco (lbs.)
Ontario	1.11	3 2	0.4	1.8
Quebec..........	1.68	1.9	0.28	2.4
New Brunswick . .	0 89	0.66	0 08	2 17
Nova Scotia	0.93	0.7	0 07	1 7
P. E. Island	0.52	0.46	0.03	1.4
Manitoba..... ..	0 68	1.7	0.06	2 6
Brit Columbia ..	1.45	3 77	0.62	3.0

In all probability this proportion holds in 1898 as in 1886; and Mr. Johnson's conclusions are still true:—

"Ontario drinks nearly three times more beer than spirits; Quebec, nearly as much spirits as beer; New Brunswick, more spirits than beer; Nova Scotia, more beer than spirits; Prince Edward Island, more spirits than beer; and Manitoba and British Columbia, more beer than spirits," p. 36. To which we might add that, according to this shewing, Prince Edward Island and New Brunswick are the most temperate of the provinces.*

*The consumption of spirits in the Maritime Provinces and in Quebec is probably greatly underestimated. The figures above shew only the consumption on which duty was paid; but there has always been a large amount smuggled into these provinces from St. Pierre which exists practically as an entrepot for smuggling. Probably 15/16ths of the imports of the island are smuggled into Canada and Newfoundland. In 1885 the amount intended to be smnggled exceeded that proportion. It is said that half the spirits and tobacco consumed in Quebec pays no duty. Since 1890 the import trade of St. Pierre has fallen 50 per cent. in consequence of the increased activity of the Canadian revenue cruisers preventing the usual exports.

It is, unfortunately, not possible to compare the quantities consumed of the articles enumerated with their retail prices to ascertain exactly the relation between prices and consumption. Where prices have fallen, it is generally assumed that the wholesale prices have fallen further and more rapidly than retail prices, though, in the case of sugar, all but the very poorest who may buy in very small quantities have benefitted to the full extent of the fall. Where prices have risen, retail prices may have risen higher than wholesale, or not so far, according to circumstances. Tobacco has probably risen higher in retail price than in wholesale; but the dealers in cigarettes last year were not able to raise prices to follow the wholesale price. The following comparison, however, is with Montreal wholesale prices as stated in the Statistical Year Book, 1896:—

CONSUMPTION AND PRICES.

YEAR	Coffee		Sugar.		Tea.		Tobacco.		Spirits.	
	Consumption per head, lbs.	Price per lb.	Consumption per head, lbs.	Price per lb.	Consumption per head, lbs.	Price per lb.	Consumption per head, lbs.	Price per lb.	Consumption per head, gal.	Price per gal.
1880	.4	27 cts.	26	10½ cts	2.7	51	1.94	54 cts	0.71	$1 50
1881	.47	25	31	10	3.8	52	2 03	55¼	0.92	1.60
1882	.71	23	30	9½	4.3	51	2.15	57½	1.01	1.60
1883	.6	22	34	9	4 0	51	2.28	47	1.09	1.60
1884	.53	21	38	7⅜	3.8	51	2.48	53¼	1.00	1.60
1885	.94	20	43	7	4.0	51	2.62	51	1.13	1.67
1886	.85	19	38	6⅛	4.9	49	2.05	53	0.71	1 81
1887	.41	24	43	6¾	3.8	43	2.06	51	0 75	1.81
1888	.6	25	43	7¾	3.7	45	2.09	51	0 64	1 81
1889	.66	26	47	8	3 6	45	2.15	51	0.73	1.83
1890	.66	26	35	6¾	3 8	45	2.14	51	0.88	1.84
1891	.69	27	40	6	3.7	42	2 29	53½	0.74	2.48
1892	.73	29	68	4½	4.4	39	2.29	56	0.70	2 88
1893	.77	29	51	$4\frac{8}{15}$	3.6	38½	2.31	54½	0.74	2.53
1894	.7	28	61	$4\frac{1}{15}$	4.1	38½	2.26	53½	0.74	2 51
1895	.72	27	70	4	4.0	35½	2.16	56	0 67	2 51
1896	.70	26	47	4⅛	4.4	33½	2.12	56	0.62	2.68

From this table it appears that though the price of coffee has not declined the consumption has increased 80 per cent., shewing at once an increased desire for coffee and a larger spending power in the community. This is probably a real increase in the consumption of the nation and not a transfer of taste; for cocoa and tea, the substitutes for coffee, have also been consumed in increased amounts, and there has been no such diminution of consumption of alcoholie drinks, for which coffee may be regarded as a substitute, as would set free such an amount of consuming power as would purchase the additional quantity of coffee. On the contrary, although the consumption of spirits has declined somewhat (13 per cent. since 1880), more is being spent on spirits to-day per head than in 1880. The price has increased 78 per cent., and had the consumption moved downwards at the same rate as the price moved upwards, the quantity used in 1896 should have been 44 per cent. less than in 1880. The decrease, instead of shewing a diminution of consumption power, indicates either an increase of money to spend or a growing desire on the part of the people for spirits such as would lead them to transfer their taste to alcohol from some other article. In face of the temperance sentiment of the country, it is improbable that the desire has increased, and we may safely conclude that the relation between consumption and prices of spirits indicates increased consumption power. The slight increase in the consumption of tobacco (11 per cent.), in spite of a rise in price, points to the same conclusion, viz, that the nation is growing more prosperous and has a larger income to expend. On the other hand, the increased consumption of tea and sugar justify no such conclusion. They, of course, indicate a higher level of general well-being, but not an increased consumption power on the part of the community. They afford no evidence against such an increase of income; they simply do not afford any evidence in its favor. The consumption of sugar has increased almost in the same rates as the price has declined. The consumption of 1895 has risen 168 per cent.; the price has declined (1895 price) 62 per cent. The consumption has risen just 5 per cent. more than the decline of

price warranted—if the community was to continue to spend the same money per head in 1895 as in 1880. Tea, however has not increased so much as the price has declined. The consumption is 48 per cent. greater than in 1880, but the 1895 price is 35 per cent. lower than the 1880 price. To preserve the same expenditure of income on this article the consumption should have risen 54 per cent., or 6 per cent. more than it has risen.

From this comparison of consumption and prices it is evident that there has been not only an increase of well-being due to the larger quantity of these commodities used, but an increase of consumption power as well, and judging from the instances before us, an increase of consumption power of considerable extent. We can carry the investigation a little further, to find out, so far as figures can tell us, how far the well-being of the community has increased. The most obvious method of estimating this increase is by constructing an index number for consumption. Into the problem whether a permanent index number of consumption is possible, it is not necessary to enter; the following attempt is intended only as a method of illustration, not as an indication of cause. It is the more important to state this limitation, as the year 1880 was, as the table shews, a year of very low consumption—a fact which was not apparent to the writer till this calculation, the last made for this paper, was made. So long as the result is not used by politicians for partisan purposes, and is regarded merely as a summary of the earlier table, it does not matter much which year is taken.

The method of construction was to take the seven articles—tea, coffee, sugar, dried fruits, spirits, beer and tobacco—as typical of the consumption power of the community, and to take the quantity consumed per head in 1880 in each case as equal to 100 —the sum 700 being taken as the index number of the consumption of that year. The articles are, of course, not all equally important, and therefore it must be repeated that the index number is intended for purposes of illustration only :—

INDEX NUMBER OF CONSUMPTION IN CANADA.

YEAR.	Tea.	Coffee.	Sugar.	Dried Fruits.	Spirits.	Tobacco.	Beer.	T'l Index Number.
1880	100	100	100	100	100	100	100	700
1881	140	117	119	159	129	106	101	871
1882	159	177	115	178	142	113	122	1006
1883	148	150	130	210	153	120	128	1039
1884	140	132	146	273	141	131	129	1092
1885	148	235	163	215	159	137	117	1174
1886	181	212	146	189	100	107	126	1071
1887	140	102	163	221	105	108	136	975
1888	137	150	163	236	90	110	144	1030
1889	133	165	180	242	109	113	144	1086
1890	140	165	134	247	124	112	149	1071
1891	137	172	153	252	104	120	168	1106
1892	162	182	261	247	98	120	156	1226
1893	133	192	192	231	104	124	154	1130
1894	151	175	234	278	104	118	162	1222
1895	148	180	268	273	94	113	154	1231
1896	167	175	180	294	87	111	155	1169

The year 1880 is evidently not an average year, and there were probably trade influences at work inducing a small importation. And it is to be remarked that the figures on which these index numbers are originally based are figures of trade and not of consumption. In order to attain something like strict accuracy by eliminating the effects of anticipatory importations to avoid a threatened tax, and such like influences visible in all trade returns, it would be necessary to make the consumption for each year the average of a period of three or four years—thus the figures for 1886 would be the average of 1884, 1885 and 1886; the figures for 1887 the average of 1885, 1886, 1887. But such exactitude would be tedious, and the process might be liable to the objection that it sought to attain a greater degree of accuracy than the nature of the subject admits.

Within the limits set down this index number illustrates the steady growth of the national prosperity and well-being—a movement not uniform or without backward steps—but none the less indicating that the command the nation has over the material sources of satisfaction has increased.

II.—On a Test, by the Freezing-Point Method, of the Ionization Coefficients Determined by the Conductivity Method, for Solutions Containing Potassium and Sodium Sulphates.—By E. H. Archibald, M. Sc., *1851 Exhibition Science Scholar, Dalhousie College, Halifax, N. S.*

(Communicated by Prof. J. G. MacGregor; Received September 15th, 1898.)

The experiments described below were undertaken, at e suggestion of Prof. J. G. MacGregor, for the purpose of testing the values of the ionization coefficients obtained by means of his graphical method,* in the case of a mixture of solutions of two electrolytes with a common ion, by employing them in the calculation of the depression of the freezing-point, and comparing the calculated values with values obtained by experiment.

The time at my disposal was very limited, and in consequence I was able to make the test only in the case of equimolecular solutions of two electrolytes. Potassium and sodium sulphates were selected as the electrolytes, not because of their being the most suitable for the purpose, but because I had been observing their conductivity and had already obtained some of the requisite data.

As, in determining the depression of the freezing-point, the solutions must be at a temperature of about 0° C., it was necessary that the ionization coefficients should be determined for approximately the same temperature. Both the specific conductivities of simple solutions of the two electrolytes throughout the range of concentration of the simple solutions used in preparing the mixtures, and their equivalent conductivities at infinite dilution, had therefore to be determined for 0° C., as well as the depression of the freezing-point for the mixtures. In

*Trans. N. S. Inst. Sci., 9, 101, (1895-6).

addition, in order to determine how closely the depression in the case of simple solutions can be calculated by means of ionization coefficients determined by conductivity measurements, I observed the depression in the case of simple solutions also.

The work involved in making the desired test therefore included the following:—(1) The purification or testing of the materials; (2) the preparation and analysis of series of simple solutions and the preparation of the mixtures; (3) the measurement of the conductivity of series of simple solutions at 0° C.; (4) the determination of the equivalent conductivity at 0° C. of the two electrolytes at infinite dilution; (5) the calculation of the ionization coefficients of the simple solutions; (6) the measurement of the depression of the freezing-point for the simple solutions; (7) the calculation of the depression for the simple solutions by means of the ionization coefficients obtained from the conductivity measurements; (8) the measurement of the depression of the freezing-point in the case of the mixtures; (9) the determination of the ionization coefficients of the electrolytes in the mixtures, and (10) the calculation of the depression of the freezing-point of the mixtures by means of these coefficients.

The Materials.

The salts were obtained as chemically pure from Eimer and Amend of New York, and were re-crystallized carefully three times, after which treatment no appreciable impurities could be detected.

he water used was purified by Hulett's* method, except that a block tin condenser was employed instead of a platinum one. Portions of the distillate were treated in the same manner as to exposure to air, etc., as a solution would be, and their conductivity measured. It was found to vary from 0.88×10^{-10} to 0.96×10^{-10}, expressed in terms of the conductivity of mercury at 0° C. It was kept in bottles which had been used for this purpose for several years.

---

*Journ. Phys. Chem. 1, 91, (1896).

Preparation and Analyses of Solutions.

The potassium sulphate solutions were prepared by adding to water a known weight of anhydrous salt which had been dried to constant weight in an air bath, so as to form a known volume of solution at 18° C. In the case of the sodium sulphate, a solution was prepared, and analysed by gravimetric determination of the sulphuric acid present in a known volume of solution. Several solutions of both salts of different concentrations were prepared in the above manner, and others were prepared from these by addition of water, their concentrations being calculated. Check analyses were made whenever any portion had gone through two or three dilutions, and if found necessary the calculated concentrations were corrected from these results.

The complex solutions were prepared by mixing equal volumes of the constituent solutions at 18° C., the same precautions being observed for securing equality of volume of the constituents as are described in a former paper communicated to the Institute on the conductivity of these salts.*

The concentrations of the solutions at 18° C. would, of course, be slightly less than their concentrations at 0° C., but with solutions as dilute as those which I used, the difference could hardly affect the third significant figure.† I have therefore regarded the concentrations at the two temperatures as the same.

As the method of calculation required a knowledge of any appreciable change of volume which might occur on mixing, simple solutions of each of the salts were prepared, and density determinations were made of such solutions before and after mixing. These measurements were carried out at 18° C. with Ostwald's form of Sprengel's Pycnometer. They might be in error by about 5 in the fifth decimal place. No change of volume

---

*Trans. N. S. Inst. Sci., 9, 291, (1897-8).

†From Forch's observations on the thermal expansion of solutions of potassium sulphate (Wied. Ann., 55, 100 (1895)), and Marignac's on sodium sulphate (Ann. Chim. Phys., (4), 22, 385, (1871)), I find that the difference of temperature referred to would affect the third significant figure of the concentrations only in the case of the stronger solutions examined, and in the case of these only to the extent of 1 or 2 units.—J. G. M.

was found to occur on preparing the most concentrated mixture examined, which would appreciably affect its concentration with respect to the two electrolytes, when calculated on the assumption that no such change of volume occurred.

Method of Measuring Conductivity.

The method used was Kohlrausch's Telephone method, and the apparatus was the same as described in the paper just referred to.

Two electrolytic cells were used, one for strong, the other for more dilute solutions. The first was U-shaped of the form shown by Ostwald in his Physico-Chemical Measurements, page 226, Fig. 178. The second was cylindrical, about 14 cm. long, with an internal diameter of 3.3 cm. It was provided with circular electrodes of stout platinum foil not easily bent. The stout wire supports of these electrodes were fused into glass tubes which passed through, and were sealed to, the ebonite cover of the cell. The electrodes were kept firmly in position by means of a rubber band passing over the cover and around the bottom of the cell. This cell being long and of the same diameter throughout, could, by variation of the distance between the electrodes, be used for solutions extending through a wide range of dilution.

The platinizing of the electrodes was carried out as described in the paper cited above.

The water-bath described in the above paper was used for these experiments also, modified, however, when working at 0° C. as follows :—A cylindrical screen made of wire gauze about 15 cm. in diameter was hung from a support so as to reach from the top, to within 6 or 8 cm. of the bottom, of the bath. Inside this, the electrolytic cell containing the solution to be measured, was placed, while outside was a mixture of snow and a very little sodium chloride. The screen thus prevented the snow from coming into contact with the cell, while the water around it could be thoroughly stirred. By varying the amount of salt the temperature could be kept within a twentieth of a degree of

zero for half an hour at a time. An error of this amount in the determination of the temperature of the solution would cause an error of about 0.1 per cent. in the determination of the resistance. The temperature of the room in which the observations were made was from 2° to 5° C. That one might be sure that the temperature of the solution to be measured had come to be that of the bath, measurements of the resistance were made at short intervals, and that reading taken which was found to be constant for successive intervals. The thermometer used was graduated to tenths of a degree centigrade, and could easily be read to twentieths. Its errors had recently been determined at the Physikalisch-Technische Reichsanstalt, Berlin.

The factor for reducing the observed conductivities to mercury units was found by plotting observed conductivities at 18° C. against concentrations, reading off from these curves the conductivity values for concentrations examined by Kohlrausch, and comparing them with his results. The value thus obtained was found to be the same for each salt and to be practically constant throughout the concentration range of my experiments. As the cell was of glass the reduction factor would not be appreciably different at 0° C. from what it was found to be at 18° C. To make sure that no change occurred in the position of the electrodes during the course of the experiments that would appreciably affect the reduction factor, every second or third solution was measured at 18° C. before reducing its temperature to 0° C., and the value of the conductivity obtained was compared with that previously obtained at the same temperature.

Determination of equivalent conductivity at infinite dilution for 0° C.

For this purpose a series of simple solutions of each electrolyte, of concentrations ranging from 0·01 to 0·0001 gramme-equivalents per litre, were prepared, and their conductivities were measured both at 18° C. and at 0° C. The conductivity of the water used in their preparation was also measured at both temperatures and subtracted in each case from the conductivity of

the solution. The following table gives the results of the observations together with the values of the temperature coefficients, $(\mu_{18}-\mu_0)/\mu_{18}$. Concentrations are expressed in gramme-equivalents of anhydrous salt per litre and conductivities in terms of 10^{-8} times the conductivity of mercury at 0° C. The conductivities at 18° were tested by comparison with Kohlrausch's values, these values when plotted on coordinate paper being found to lie practically on the same curve as mine.

TABLE I.

Potassium Sulphate Solutions.				Sodium Sulphate Solutions.			
Concentration at 18°C.	Equivalent Conductivity (μ). At 18°C.	Equivalent Conductivity (μ). At 0°C.	$\frac{\mu_{18}-\mu_0}{\mu_{18}}$	Concentration at 18°C.	Equivalent Conductivity (μ). At 18°C.	Equivalent Conductivity (μ). At 0°C.	$\frac{\mu_{18}-\mu_0}{\mu_{18}}$
.010	1099	687	.375	.010	907	555	.388
.008	1116	698	.375	.008	919	562	.389
.005	1142	716	.373	.005	946	577	.390
.004	1155	723	.374	....	....	....	....
.002	1180	740	.373	.002	981	596	.393
.001	1206	757	.372	.001	997	604	.394
.0008	1213	762	.372	.0008	1003	607	.395
.0006	1221	768	.371	.0006	1008	609	.396
.0005	1225	771	.371	.0005	1012	611	.396
.0004	1230	775	.370	....	....	....	....
.0002	1240	781	.370	.0002	1027	620	.396
.0001	1248	786	.370	.0001	1036	626	.396

It will be seen that the temperature coefficients for potassium sulphate solutions diminish with increase of dilution while those for sodium sulphate increase. This result* was so

* The results of this table are in close agreement with those obtained by Deguisne (Dissertation, Strassburg, 1895), of which Mr. Archibald was not aware.—J. G. M.

unexpected that I thought it well to repeat the observations, the result being substantiated by the repetition.

It will be seen also that in both cases the coefficients reach constant values as concentration is diminished, in the case of $\frac{1}{2} K_2 SO_4$ from a concentration of ·0004 on, in that of $\frac{1}{2} Na_2SO_4$ from ·0006 on. Assuming then that these values will hold for infinite dilution, the equivalent conductivities at infinite dilution for 0° C. may be determined from Kohlrausch's values* for 18°C, viz., 1270×10^{-8} and 1070×10^{-8} for $\frac{1}{2}K_2 SO_4$ and $\frac{1}{2} Na_2 SO_4$ respectively. They were found thus to have the values 800×10^{-8} and 646×10^{-8} respectively, expressed in terms of the conductivity of mercury at 0°C.

Determination of the Ionization coefficients of simple solutions.

Both for the purpose of finding how closely the lowering of the freezing point could be calculated for simple solutions and for the purpose of determining the ionization coefficients of the electrolytes in the mixtures, it was necessary to know the ionization coefficients of a sufficiently extended series of simple solutions of the two electrolytes. The following table contains the observations of conductivity made for this purpose, together with the values of the ionization coefficients calculated on the assumption that for simple solutions they are equal to the ratios of the equivalent conductivity to the equivalent conductivity at at infinite dilution. The table gives also the ionization coefficients at 18°C. obtained from the conductivity observations of former papers.† These quantities are not needed for the present purpose. But the knowledge of the ionization coefficients at 0° enables us to determine how in the case of the electrolytes under consideration the state of ionization in simple solutions varies with the temperature. Concentions and conductivities are expressed in terms of the same units as in Table I.

* Wied. Ann., 50, 406, (1893).

† Trans. N. S. Inst. Sci., 9, 291 and 307, (1897-8.)

TABLE II.

Concentration at 18°C.	Equivalent Conductivity at 0°C.		Ionization Coefficients.			
			K_2SO_4.		Na_2SO_4.	
	½ K_2SO_4.	½ Na_2SO_4.	At 18°C.	At 0°C.	At 18°C.	At 0°C.
.050	604.2	486.0	.757	.755	.733	.752
.055	598.0	480.0	.750	.748	.728	.743
.060	594.1	475.5	.745	.743	.723	.736
.070	585.4	466.5	.736	.732	.715	.722
.080	577.5	460.0	.723	.722	.703	.712
.100	564.0	448.5	.706	.705	.686	.694
.125	547.5	434.0	....	.684	....	.672
.150	535.0	422.5	....	.669	....	.654
.200	516.0	403.1	.650	.645	.601	.624
.250	503.0	387.4	.634	.629	.586	.600
.300	493.0	373.5	.620	.616	.570	.578
.350	485.0	362.4	.605	.606	.556	.561
.400	478.0	353.0	.595	.598	.545	.546
.450	473.0	345.5	.587	.591	.533	.535
.500	470.0	339.6	.580	.588	.522	.525
.600	466.0	330.0	.567	.583	.506	.511
.700	464.0	324.2	.551	.580	.498	.501

It appears from these results that in the case of solutions of potassium sulphate the ionization coefficient increases very slightly with rise of temperature between 0° and 18°C from a concentration of 0.05 to one of about 0.35, and that from this n tration to one of at least 0.7 it decreases, the magnitude of the decrement increasing rapidly with the concentration, and amounting at a concentration of 0.7 to 5 per cent. In the case of sodium sulphate, the coefficient diminishes with rise of

temperature throughout the whole range of concentration observed, the amount of the decrement diminishing with increase of concentration, until at a concentration of 0.7 it is only 0.6 per cent.

Method of measuring Depression of the Freezing-point.

Of the different methods described for the determination of the freezing point of salt solutions, that of Loomis* appeared to me the best, and to give the most concordant results. His method was accordingly followed in making the measurements below.

As it is most essential that the temperature of the room where the observations are made should be near zero and as constant as possible, the measurements were carried out during the winter months in a basement room of Dalhousie College building, where it was found possible to keep the temperature below 2°C and constant to within 0.5 of a degree for a couple of hours at a time. No measurements were made while the temperature of the room was above 2°C.

The thermometer was of the ordinary Beckman form, graduated to 0.01 of a degree. No reading microscope being available, I had to be satisfied with the use of an ordinary hand lens for this purpose. Nevertheless, as the divisions of the scale were about 0.6 mm. in length, I am quite satisfied that I was able to read the temperatures to at least .001 degree. The following readings of the thermometer made in an experiment for determining the freezing point of water would seem to imply that I succeeded in reading even more closely :—2.3415, 2.3410, 2.3420, 2.3415, 2.3420. Mean reading, 2.3416. Greatest divergence from mean, .0006.

The thermometer had never been calibrated, and as apparatus for this purpose was not available, I did not attempt to calibrate it myself. The length of scale used for the following measurements, however, was less than what corresponded to 1.4 degree, and for the more dilute solutions, say below 0.1

* Phys. Review, 1, 199 and 274 (1893) and 3, 270 (1896).

gramme-equivalent per litre, less than what corresponded to 0.2 of a degree.

The freezing and melting baths were each of earthenware, about 32 cm. long and with an internal diameter of about 9 cm. In the former was a mixture of snow and water with enough common salt added to keep the temperature at about —12°C. The latter contained a mixture of snow and water, the temperature of which was about 0.2°C.

The protection bath, which was of glass 35 cm. deep and 8 cm. in diameter, was provided with a covering of felt to minimize the effect of the surrounding air. It contained a mixture of snow and water with sufficient salt added to keep the temperature from 0.3 to 0.28 degree below the freezing point of the solutions to be measured. After some experience had been gained, little trouble was found in keeping the temperature of this bath constant within a twentieth of a degree during several observations of any one solution.

The freezing tubes first tried were of the following dimensions:—the inner one 22 cm. long with an external diameter of 2.4 cm., the outer one 20 cm. long with an internal diameter of 2.7 cm., the thickness of the glass of both tubes being 1 mm. There was thus an air space of about 1.5 mm. between the tubes. This was found to be too great as shewn by its being difficult to prevent ice from forming around the bulb of the thermometer despite the most vigorous stirring. The next ones tried were as follows:—The inner tube was 28 cm. long, with an external diameter of 2.7 cm., the outer tube 26 cm. long with an internal diameter of 2.85 cm., the thickness of the glass being the same as before. There was thus an air space of about 0.7 mm. between the tubes. This was found to be hardly enough as there was a tendency for the ice to form on the walls of the tube and thus cause much delay. As I worked with 75 c.c. of solution, the greater length of these tubes allowed the solution to be immersed well into the bath, rendering it almost free from the influence of the outside temperature. The

inner tube was therefore retained and an outer tube provided of about the same length and thickness of walls, but with an internal diameter of 2.88 cm., thus leaving an air space of about 0.9 mm. between the tubes. This gave complete satisfaction. With uniform stirring no tendency was observed for the ice to form on the walls of the tube or on the bulb of the thermometer, or to freeze in a mass. The inner tube had its lower end re-entrant, as recommended by Loomis.

I should like to draw attention to the importance of having the air space between the two tubes of the proper size. If the importance of this point has been noted by former observers it has escaped me.

The hammer used for tapping the thermometer was part of a small electric bell and was covered with a piece of thick rubber tubing. It was found to be very essential to drive the hammer so that the blows on the thermometer might be of uniform strength. Some difficulty was met with in attaining that end; but by careful attention to the strength of the current what appeared to be sufficient uniformity was attained.

The stirrer was of the ordinary ring form, the upright rod passing through a glass tube, the upper end of which was constricted, and the lower so far from the solution that the wetted portion of the stirrer could not touch it. A stop on the upright rod limited the extent of the stroke so that the ring would not leave the solution, and ensured the equality of the strokes. It was worked by hand as uniformly as possible.

The over-cooling was seldom over 0.1 degree, owing doubtless to the low temperature of the room in which the observations were made. There was consequently no need of correcting for over-cooling.

The freezing point of water was determined each day before determining that of the solutions, and in the event of any appreciable change occurring in the atmospheric pressure during the observations on the solutions, the observation on water was repeated.

Observed and Calculated Values of the Depression of the Freezing-point for Simple Solutions.

The following table contains the observations of the depression of the freezing-point of simple solutions, together with observations on solutions of about the same concentration by Loomis* and Jones† for comparison. The depressions are expressed in centigrade degrees.

TABLE III.

Concentration gr.-eq. / litre.	Depression of Freezing-point.		Observer.
	K_2SO_4.	Na_2SO_4.	
.03949	.0975	....	Jones.
.04	.0952	.0974	Loomis.
.050	.1185	.1191	Author.
.055	.1296	.1304	"
.0579	.1397	....	Jones.
.060	.1407	.1416	Author.
.070	.1629	.1638	"
.07556	.1792	....	Jones.
.080	.1851	.1856	Author.
.10	.2307	....	Jones.
.10	.2271	.2297	Loomis.
.100	.2285	.2286	Author.
.116	.2655	....	Jones.
.19685	.42525	....	"
.20	.4317	.4340	Loomis.
.200	.4322	.4330	Author.
.250	.5295	.5300	"
.300	.6240	.6252	"
.350	.7196	.7157	"
.40	.8134	.8141	Loomis
.400	.8128	.8100	Author.
.450	.9063	.8968	"
.500	.9950	.9875	"
.60	1.1672	1.1604	Loomis.
.600	1.170	1.155	Author.
.700	1.341	1.323	"

* Phys Review, 3, 277, (1896).

† Ztschr. f. phys. Chem., 11, 536, (1893).

It will be seen, especially if the above results be plotted, that all three sets of observations agree very well with one another, but that mine agree better with Loomis's than with those of Jones. Their agreement with Loomis's is very close.

The following table contains the observed and calculated values of the freezing-point depressions for simple solutions, with the differences expressed as percentages of the observed values. In the calculations Van 't Hoff's constant was taken to be 1.86, and the expression used for the depression was

$$\Delta = 1.86\ (1+2\alpha)\ N/2,$$

where N is the concentration of the solution in gr.-equivalents per litre.

TABLE IV.—DEPRESSION OF FREEZING-POINT.

Concentra. (gr.-eq. / l.)	Potassium Sulphate Solutions.			Sodium Sulphate Solutions.		
	Observed.	Calculated.	Diff. per cent.	Observed.	Calculated.	Diff. per cent.
.050	.1185	.1168	—1.4	.1191	.1164	— 2.3
.055	.1296	.1277	—1.5	.1304	.1272	— 2.5
.060	.1407	.1387	—1.4	.1416	.1379	— 2.6
.070	.1629	.1604	—1.5	.1638	.1591	— 2.9
.080	.1851	.1818	—1.8	.1856	.1803	— 2.9
.100	.2285	.2241	—1.9	.2286	.2221	— 2.9
.200	.4322	.4259	—1 5	.4330	.4181	— 3.4
.250	.5295	.5250	—0.8	.5300	.5115	— 3.5
.300	.6240	.6227	—0.2	.6252	.6015	— 3.8
.350	.7196	.7200	+0.1	.7157	.6907	— 3.5
.400	.8128	.8169	+0.5	.8100	.7782	— 3.9
.450	.9063	.9131	+0.8	.8968	.8663	— 3.4
.500	.9950	1.0118	+1.7	.9875	.9532	— 3.5
.600	1.170	1.209	+3.3	1.155	1.128	— 2.3
.700	1.341	1.406	+4.9	1.323	1.303	— 1.5

The above table shews the degree of accuracy with which the depression of the freezing-point can be calculated in the case of simple solutions. If the ionization coefficients for the mixtures are determined by Prof. MacGregor's method as closely as they are for the simple solutions by putting $a = \mu/\mu_\infty$, the differences between the calculated and observed values of the depressions in the case of the mixtures may be expected to be no greater than those of the above table.

Depression of the Freezing-point by the Mixtures.

The following Table contains the observed and calculated values of the depression of the freezing-point in the case of the mixtures examined. The observations were made in the manner described above. The calculations were made by the following formula for which I am indebted to Professor MacGregor :—

$$\Delta = 1.86\ (1 + a_1 + a_2)\ N/2$$

where a_1 and a_2 are the ionization coefficients of the respective electrolytes in the mixture and N the number of gramme-equivalents per litre in the solutions mixed, which were in all cases equimolecular. This expression may be readily obtained as follows :—In each litre of the mixture there will be N/4 gramme-molecules of each electrolyte. There will therefore be $(1 - \alpha_1)$ N/4 and $(1 - \alpha_2)$ N/4 undissociated gramme-molecules of the respective electrolytes, and, if we assume the ionization in each case to be complete, $3\alpha_1$ N/4 and $3\ \alpha_2$ N/4 free gramme-ions. Hence the total number of undissociated gramme-molecules and free gramme-ions will be $(1 + \alpha_1 + \alpha_2)$ N/2, and the expression for the depression will consequently be as above.

The first column of Table V gives the concentration of the solutions mixed, in gramme-equivalents of anhydrous salt per litre at 18°C. The fifth and sixth columns give the ionization coefficients of the respective electrolytes in the mixture at 0°C as determined by Prof. MacGregor's method. The second, third and fourth give the quantities obtained directly by this method, viz., the common concentration of ions, and the dilutions of the respective electrolytes in the mixture. (By the concentration of

ions in the mixture is meant the number of dissociated gramme-equivalents of either electrolyte in any volume of the mixture divided by the volume of that portion of the mixture which may be regarded as occupied by it. The dilutions of the electrolytes in the mixture are the volumes of such portions divided by the number of gramme-equivalents of the electrolytes they contain. The product of these two quantities for each electrolyte gives the ionization coefficient of such electrolyte in the mixture.) The data of the other columns are sufficiently specified by the headings.

TABLE V.

Concentration of constituent solutions at 18°C. (gr.-eq. per l.)	Concentration of ions in mixture at 0°C.	Dilution in Mixture at 0°C.		Ioniza. Coeffts. in Mixture at 0°C.		Depression of Fr.-point.		
		$\frac{1}{2}K_2SO_4$.	$\frac{1}{2}Na_2SO_4$.	K_2SO_4	Na_2SO_4.	Observed	Calculated.	Diff. per cent.
.050	.0377	20.04	19.96	.7555	.7525	.1187	.1166	— 1.8
.055	.0410	18.22	18.14	.7470	.7437	.1299	.1274	— 1.9
.060	.0443	16.72	16.60	.7407	.7354	.1411	.1382	— 2.1
.070	.0509	14.40	14.18	.7330	.7218	.1634	.1598	— 2.2
.080	.0574	12.60	12.40	.7232	.7118	.1854	.1812	— 2.3
.100	.0698	10.18	9.92	.7106	.6924	.2284	.2235	— 2.1
.150	.0998	6.73	6.60	.6717	.6587	.3327	.3250	— 2.3
.200	.1266	5.10	4.90	.6457	.6203	.4324	.4215	— 2.5
.250	.1528	4.10	3.90	.6265	.5959	.5295	.5166	— 2.4
.300	.1784	3.46	3.21	.6173	.5727	.6246	.6110	— 2.2
.400	.228	2.63	2.37	.5996	.5404	.8096	.7961	— 1.7
.500	.227	2.12	1.88	.5872	.5208	.9885	.9802	— 0.8
.600	.327	1.79	1.54	.5853	.5036	1.1604	1.1657	+ 0.5
.700	.376	1.54	1.31	.5790	.4926	1.3300	1.3489	+ 1.4

If we compare the percentage differences of the above table with the corresponding differences in the case of the constituent simple solutions (Table IV, p. 45), it will be seen that the former are in general equal to the arithmetic means of the latter. Hence the depressions of the freezing-point of the mixtures have been calculated with the same degree of accuracy as those of the simple solutions.

The test which has thus been applied to Prof. MacGregor's method of determining the ionization coefficients in a solution containing two electrolytes with a common ion, and which the method has completely satisfied, is, however, not a severe one. It was intended, after the experiments on equimolecular solutions, to take up mixtures of solutions of different concentration with respect to the two electrolytes. Unfortunately I was prevented from doing so by lack of time.

In conclusion, I wish to express my thanks to Prof. MacGregor for valuable suggestions kindly given.

III.—On the Conductivity, Specific Gravity and Surface Tension of Aqueous Solutions Containing Potassium Chloride and Sulphate.—By James Barnes, B. A., *Dalhousie College, Halifax, N. S.*

(Communicated on May 10th, 1899, by Prof. J. G. MacGregor.)

In papers read before this Society it has been shown that it is possible, by the aid of the dissociation theory of electrolytic conduction, to predict the conductivity and other physical properties of a solution containing two[1] chlorides or two[2] sulphates, with data as to the conductivity and the other physical properties obtained by observations on simple solutions of these salts.

At Prof. MacGregor's suggestion, I have carried out the experiments described in this paper, with the object of testing this possibility for a solution containing a chloride and a sulphate with a common cation.

The electrolytes selected were potassium chloride and sulphate. The observations on conductivity and specific gravity were made by the writer, while [3]Rother's observations on surface tension were used. The observations were made in the Physical and Chemical Laboratories of Dalhousie College, Halifax, during the session of 1898–99.

Apparatus and Methods.—Chemical Analysis.

The salts were obtained from Eimer & Amend of New York, as chemically pure. They were re-crystallized twice. No traces of iron or sodium were found in the salts. For the detection of iron, the ammonium sulphocyanide test was applied; for sodium, the flame test.

The water used in making the solutions was purified by boiling ordinary distilled water with a few

---

[1] McIntosh, Trans. N. S. Inst. Sci., 9, 120, 1895-6.
McKay, Trans. N. S. Inst. Sci., 9, 321, 1897-8.

[2] Archibald, Trans. N. S. Inst. Sci., 9, pp. 291, 307, 335.

[3] Wied. Ann., 21, 576, 1884.

grammes of barium hydroxide in a copper boiler lined with tin, and condensing in a block tin worm. The first portion of about 200 cc. that came off, was always thrown away. The water thus purified had at 18° C. a conductivity ranging from $.95 \times 10^{-6}$ to 1.03×10^{-6} expressed in [1]Kohlrausch's new unit (Ohm^{-1} $cm.^{-1}$)

The amount of potassium chloride in a solution was determined volumetrically by Mohr's method. Two solutions of KCl, about deci-normal, were made by direct weighing of the pure fused salt. These were employed in obtaining a standard solution of $Ag\,NO_3$. Weaker solutions of $Ag\,NO_3$ were obtained by known dilution from this standard one. Neutral potassium chromate was used as the indicator. The following results will show with what accuracy this method of titration could be performed:

(1)	1 cc. solution contained......	0.02444
(2)	1 cc. " "	0.02445
(3)	1 cc. " "	0.02448
	Mean......	0.024457

Thus it seems that results which differed from the mean value by about 0.1 per cent could be obtained.

The amount of potassium sulphate in a solution was determined gravimetrically by precipitation with barium chloride. Results in this case were found to differ about 0.1 per cent from the mean value, as shown in the following example:

(1)	1 cc. solution contained......	0.05229
(2)	1 cc. " "	0.05238
(3)	I cc. " "	0.05235
	Mean......	0.05234

The burettes and pipettes used in the above analyses were calibrated by the weight of distilled water they delivered. The burettes had a capacity of 50 cubic centimetres, and were graduated to a tenth of a cubic centimetre. By means of an Erdmann

[1] Kohlrausch u. Holborn: Leitvermögen der Elektrolyte, 1898, p. 1.

float one could read to 0.1 cc. Corrections for the volume of the water contained between every two cubic centimetre marks were found and plotted on co-ordinate paper against the reading. The pipettes were all employed as much as possible in the same way, and none required less than 40 seconds to flow out. Two flasks holding a litre and a half litre respectively, were the only ones used. These were calibrated by the weight of water they held at 18° C.

Measurement of Specific Gravity.

The specific gravity observations were made with a pycnometer of the Ostwald-Sprengel form, holding about 22 cc. All observations were made at 18° C. To obtain this temperature it was necessary, after filling the pycnometer with the solution at about this temperature, to place it in the bath described below, in which the temperature remained at 18° C. for a considerable time. After remaining in the bath fifteen minutes or more the meniscus was adjusted to the mark. If the meniscus now remained stationary for a few minutes, the pycnometer was removed, carefully cleaned and dried, and then weighed. The barometer and thermometer readings in the balance case, where the air was kept as dry as possible by means of calcium chloride, were taken, and corrections applied for the buoyancy of air. The specific gravity of a certain solution of potassium chloride was found by this method to have the following values :

(1)	1.04455
(2)	1.04458
(3)	1.04449
(4)	1.04450
Mean	1.04453

Thus results which differed by about 5 in the fifth place of decimals from the mean value could be obtained.

Measurement of Conductivity.

The method employed by Kohlrausch with the alternating current and telephone was used.

The Wheatstone's bridge consisted of four resistance coils, which were certified by Queen & Co., of Philadelphia, to be correct to one-fiftieth of one per cent, and a platinoid bridge wire wound on a marble drum. This wire had a resistance of about 0.9 ohm, and was divided into 1000 parts, each part being capable of subdivision by the eye into tenths. It was calibrated before and after the observations, by [1]Strouhal and Barus's method, ten german-silver wires of equal length, with ends firmly soldered into stout copper wire being used. Corrections were plotted against the length, and a smooth curve drawn through the points, and thus intermediate readings could be corrected. The greatest correction found was 1.2 divisions. The small induction coil used had a very rapid vibrator, and was kept in an adjoining room, that its noise might not interfere with the clearness of the sound minimum in the telephone. The telephone recommended by Ostwald, and made by Ericsson of Stockholm, was used.

With these appliances the minimum point could be determined to 0.3 of a division, corresponding to an error of 0.12 per cent in the determination of the resistance at the centre of the bridge, and 0.16 per cent at the point farthest from the centre used in the experiments.

Electrolytic Cell.

The cell in which the solutions were placed for the determination of the resistance was of the Arrhenius form, a deep cylindrical vessel, of diameter 3 cm., and depth 14 cm. The electrodes were of stout platinum foil, firmly joined by heavy platinum wire to the glass tubes. These electrodes after being well-cleaned with alcohol and a strong solution of sodium hydroxide, were platinized in a solution of platinum chloride and lead acetate. This solution was prepared from [2]Lummer and Kurlbaum's recipe. When the electrodes had received a good coating of platinum black, they were removed and well washed in hot water.

Stout copper wires, well insulated, connected this cell with the Wheatstone bridge. They had a resistance of .023 ohm.

[1] Wied Ann., 10, 326, 1880.
[2] Wied. Ann., 60, 315, 1897.

These wires, and also those between the induction coil and the Wheatstone bridge, were run parallel and close together to diminish any effects from self-induction.

Reduction Factor.

The capacity of the electrolytic cell was obtained by plotting the conductivities obtained against the concentrations. [1] Kohlrausch's values of the conductivity for various concentrations of the same salt were plotted to the same scale on the same coordinate paper. The ratio of the two conductivities for the same concentration gives the factor by which the observed values are reduced to the standard employed by Kohlrausch. This ratio was found to be practically the same for both electrolytes, and in the case of both, constant throughout my range of dilution.

Bath.

As the conductivity of a solution varies with the temperature, it was necessary to have a bath whose temperature could be kept constant for a sufficient time in which to make the measurement. Tap water, kept continually stirred by a mechanical stirrer driven by a small hydraulic motor, made an excellent bath. A thermostat was not found necessary; for, as the temperature of the room was generally near 18° C., the temperature of the bath would not change one-fiftieth of a degree in thirty minutes. The thermometer used was graduated to a fiftieth, and could easily be read to a hundredth, of a degree. This thermometer had had its errors determined at the Physikalisch-Technische Reichsanstalt, Berlin.

All solutions were allowed to remain in the bath ten minutes at least before observations were taken. After a few minutes another observation of the resistance was taken. This was done to insure that the solution had taken the temperature of the bath.

Preparation of Simple Solutions.

The method adopted was to make up a few solutions of different concentrations of each salt. These solutions were care-

[1] Kohl. u. Hol., *loc. cit.*, p. 159, tab. 2.

fully analysed. Seventy-five cc. of a solution was introduced into the electrolytic cell, and successive dilutions prepared therein by the withdrawal of a certain volume and the addition of an equal volume of water at the temperature 18° C. This process was continued till the dilution reached that of the next formerly prepared solution, when the new one was introduced and the same process repeated. After each solution had gone through two dilutions the volume removed was analysed, the result serving as a check upon the calculated strength of the solution in the cell.

Preparation of Mixtures of Solutions.

Simple solutions of each electrolyte were prepared and analysed. These were kept in the bath till they had taken the temperature 18° C., when 50 cc. of each solution was removed, and the two mixed. The 50 cc. pipette used was thoroughly washed with a portion of the solution before the removal.

Results of Conductivity Observations on Simple Solutions.

For the purpose of calculating the ionization coefficients of the salts in the mixture, it is necessary to draw curves for simple solutions of each salt, showing the relation of the dilution to the ionic concentration. The following tables give the data for the drawing of these curves, obtained from observations on the concentrations and conductivities of a number of solutions of each salt.

The dilutions are expressed in terms of litres per gramme equivalent at 18° C. The atomic weights used were relative to oxygen (16.00) and the same as employed by [1] Kohlrausch. The specific conductivities are those at 18° C, expressed in terms of 10^{-4} times Kohlrausch's new unit ($Ohm^{-1} cm.^{-1}$)

The concentrations of ions are the quotients obtained by dividing the specific conductivities by the specific molecular conductivities at infinite dilution. [2] Kohlrausch's values for the specific molecular conductivities at infinite dilution were used, namely, for potassium chloride 1312×10^{-4}, and potassium sulphate, 1350×10^{-4}.

[1] Kohl. u. Hol., *loc. cit.*, p. 205, tab. 14.
[2] Ibid., p. 200, tab. 8.

TABLE I.—Potassium Chloride (KCl).

Dilution.	Specific Conductivity.	Concentration of Ions.
497.4	2.540	.00194
331.6	3.789	.00298
221.1	5.646	.00430
147.4	8.362	.00637
98.26	12.44	.00948
93.46	13.06	.00995
62.25	19.35	.0147
41.50	28.61	.0218
27.72	42.44	.0323
22.50	51.78	.0395
18.48	62.39	.0475
15.44	74.05	.0564
15.00	76.10	.0580
10.30	108.7	.0829
10.00	111.8	.0852
6.866	159.5	.122
4.577	234.2	.178
3.051	243.8	.262
2.024	506.1	.386
1.383	724.9	.553
1.046	939.8	.716
.922	1056	.805

TABLE II.—Potassium Sulphate ($\frac{1}{2}K_2SO_4$).

Dilution.	Specific Conductivity.	Concentration of Ions.
9.661	99.22	.0735
3.336	253.4	.187
2.596	313.2	.232
1.668	458.3	.339
1.298	570.3	.422

These were the only observations made upon potassium sulphate, because E. H. Archibald[1] had made a sufficient number of observations on solutions of this salt, and his results were found to agree with mine. Archibald's results were expressed differently. The atomic weights used for determining his dilutions were relative to Hydrogen. These dilutions can be changed to the above by multiplication by the factor 1.0026. His specific conductivities were expressed in terms of 10^{-8} times the specific conductivity of mercury at 0° C. These values of the conductivity can be expressed in Kohlrausch's new unit by multiplication by 1.069×10^4. The new values for the concentration of ions can thus be calculated as in the former case. The following table gives the reduced results:

TABLE III.—POTASSIUM SULPHATE.

DILUTION.	SPECIFIC CONDUCTIVITY.	CONCENTRATION OF IONS.
100.26	11.72	.00868
66.85	16.87	.0125
40.11	27.27	.0202
33.42	32.26	.0239
20.06	51.16	.0379
15.67	63.72	.0472
12.54	78.30	.0580
10.03	95.58	.0708
8.628	110.7	.0820
7.193	130.7	.0968
5.990	152.6	.113
4.991	179.5	.133
3.466	244.4	.181
2.888	286.2	.212
2.407	334.8	.248
2.079	380.7	.282
2.005	392.8	.291
1.444	523.8	.388
1.203	610.2	.452
1.003	716.8	.531

[1] Trans. Roy. Soc. Can. (2), 3, Sec. 3, 69, 1897-8.

Method of Calculating the Conductivity of Mixtures.

According to the dissociation theory the specific conductivity of a mixture of two solutions of electrolytes is given by the equation

$$k = \frac{1}{p\ (v_1 + v_2)} \left(\alpha_1 v_1 n_1 \mu_{\infty 1} + \alpha_2 v_2 n_2 \mu_{\infty 2}\right),$$

where v_1, v_2 are the volumes, and n_1, n_2 the concentrations of the solutions mixed, $\mu_{\infty 1}$, $\mu_{\infty 2}$ the specific molecular conductivities of simple solutions of the electrolytes at infinite dilution, α_1 and α_2 the ionization co-efficients of the respective electrolytes in the mixture, and p is the ratio of the volume of the mixture to the sum of the volumes of the constituent solutions. This ratio was found, for the solutions used, to be practically equal to the unity; and as the volumes of the solutions mixed were in all cases equal, the equation applicable to my experiments becomes:

$$k = \tfrac{1}{2}(\alpha_1 n_1 \mu_{\infty 1} + \alpha_2 n_2 \mu_{\infty 2}).$$

Of the data requisite for calculating k, the n's were obtained by chemical analysis, the α's by Prof. MacGregor's method, while the μ_∞'s, in the case of sufficient dilution, might be taken to be the same in value as in the case of simple solutions of the respective electrolytes.

Determination of p.

As equal volumes of the simple solutions were mixed, the ratio expressed by p is equal to the ratio of the mean specific gravity of the constituent solutions to the specific gravity of the mixture. By referring to the following Table IV, it is at once seen that this ratio is practically equal to unity for the most concentrated solutions examined.

TABLE IV.

Simple Solutions.					Sp. Gr. of Mixture.
Concentration.		Specific Gravity at 18°.		Mean Sp. Gr.	
$\frac{1}{2}$ K_2SO_4.	KCl.	$\frac{1}{2}$ K_2SO_4	KCl		
.5998	.9558	1.0410	1.0445	1.0428	1.0427
.5998	.09454	1.0410	1.0045	1.0228	1.0229
.1035	.05412	1.0073	1.0026	1.0049	1.0050

Determination of Ionization Coefficients in the Mixtures.

The method of determining the coefficients of ionization of the two electrolytes in a mixture has been fully described by [1]Prof. MacGregor. Curves are drawn showing the relation of the dilution to the concentration of ions for simple solutions of each salt. From these curves the concentration of ions and the dilution in the regions of the mixture occupied by the respective electrolytes are found by a graphical process, and the products of these quantities give the ionization coefficients.

Results of Observations and Calculations of Conductivity of Mixtures.

Table V gives the necessary data for the calculation of the conductivity of the mixtures examined, and the results obtained. The concentrations of the constituent solutions are expressed in terms of gramme-equivalents per litre at 18° C. The regional dilutions are in litres per gramme-equivalent at 18° C. The specific conductivities are expressed as in Table I. The differences between the calculated and observed values of the conductivity are given as percentages of the observed value.

[1] Trans. N. S. Inst. Sci., 9, 101, 1895-6.

TABLE V.

Concentration of Constituent Solutions.		Concentrat'n of Ions in Mixture.	Regional Dilution.		Specific Conductivity of Mixture.		
$\frac{1}{2} K_2SO_4$	KCl.		$\frac{1}{2} K_2SO_4$	KCl.	Observed	Calculated.	Diff. per cent.
.7707	.4941	.405	1.36	1.91	536.2	537.2	+0.18
"	.09454	.264	2.22	3.03	354.1	354.5	+0.11
"	.05412	.251	2.37	3.18	337.9	337.8	−0.03
"	.01018	.235	2.55	3.43	317.9	317.2	−0.22
.5998	.9558	.528	1.01	1.45	684.0	695.9	+0.27
"	.09454	.220	2.76	3.69	295.5	296.1	+0.20
"	.05412	.206	2.98	3.89	275.5	276.4	+0.32
"	.01018	.190	3.25	4.28	255.3	255.3	±0.00
.3853	.2470	.218	2.79	3.73	288.7	289.9	+0.41
"	.02706	.138	4.75	5.97	184.0	184.6	+0.32
.2999	.2470	.193	3.21	4.23	258.6	257.7	−0.35
.1035	.9558	.400	1.38	1.94	524.3	525.2	+0.17
"	.4941	.233	2.58	3.47	303.4	303.8	+0.16
"	.05412	.0611	11.8	14.3	81.51	81 37	+0.18
"	.01018	.0431	17.4	20.4	58.42	58.27	−0.26
.05175	.02706	.0324	24.2	27.6	43.48	43.50	+0.05
"	.00509	.0231	24.7	39.4	31.11	31.04	−0.23

From this table it appears that the difference between the calculated and observed values of the conductivity for all the mixtures examined, is within, or but little beyond, the limit of the error of observation, which is estimated at about 0.25 per cent.

It might be well to note that in each series having a constant concentration of potassium sulphate, the differences seem to change from a negative to a positive per cent.[1]

Considering the many sources of error in the calculations of the conductivity. the agreement between the observed and calculated values is very satisfactory, and leads one to draw the conclusion that the conductivity of mixtures of solutions of these

[1] *Note by the communicator of the paper.*—Mr. Barnes points out that in series of mixtures whose constituent solutions have in the case of one electrolyte the same concentration (n_1 say) in all, and in that of the other a variable concentration (n_2 say), the excess *(e)* of the calculated over the observed value of the conductivity increases with n_2, being usually negative for small values of n_2 and positive for larger values. At first sight it might appear that he had over-estimated his limit of error, and that the conductivity was thus shown to be calculable only for a particular value of n_2 in each case. There are, however, two sources of error which will account for this regular progression in the relative magnitude and sign of the *e*'s, viz., (1) The employment, of the quotients of the specific equivalent conductivity by the specific equivalent conductivity at infinite dilution (μ/μ_∞) as the values of the ionization coefficients (a) for simple solutions, and (2) the impossibility of drawing with perfect accuracy the dilution-ionic-concentration curves. The more concentrated the solutions the greater will μ/μ_∞ differ from a; and the greater the liability to error in the drawing of the curves the greater the possible error in the determination of the ionization coefficients of the electrolytes in the mixture. The dilution-ionic-concentration curves are nearly rectilinear for very weak and for strong solutions but curve rapidly in the region of moderate dilution, and it is in this region that it is most difficult to draw them accurately. Hence in the case of strong solutions, the magnitude and sign of the *e*'s will be determined largely by the error due to using values of μ/μ_∞ as the ionization coefficients of the simple soiutions. In the case of moderately dilute solutions they will be determined by both sources of error. In the case of dilute solutions neither source of error will have so large an effect on the result. Hence a regular progression of the *e*'s the same in kind, may be expected in different series of mixtures of strong solutions of two given electrolytes; a regular progression may be expected also in series of moderate dilution, but since the error due to inaccurate drawing of curves will depend on the portion of the curve which is used, it may be different in kind for different series; and in sufficiently dilute solutions no regular progression is likely to occur, The most of Mr. Barnes' series are of moderate dilution, and in all of them the *e*'s show a regular progression of the same kind, as they would if the errors involved did not conflict in sign, or if the error due to the one source were large relatively to that due to the other. His series of dilute solutions exhibit the same progression in the *e*'s, but they consist of only two mixtures each. In my calculations of the conductivity of mixtures of NaCl and KCl solutions (Trans N. S. I. S., 9, 116), the three more concentrated series showed a progression of the *e*'s of the same kind, the two weakest series showed no progression. In Mr. McIntosh's calculations (*Ibid.*, 9, 132), for HCl and NaCl, the two stronger series gave a progression of the same kind, the weakest no progression. And in Mr. Archibald's calculatiens (*Ibid.*, 9, 299), for K_2SO_4 and Na_2SO_4 solutions, the four stronger series gave progressions of the *e*'s, differing in kind, and the three series of weaker solutions gave either a very doubtful progression or no progression at all. All these results are thus consistent with the assumption that this regular progression in the *e*'s is due ma nly at least to the two sources of error mentioned above. J. G. M.

salts up to an average concentration of 0.8 gramme-equivalent per litre at least, can be predicted within the limit of error of my observations.

Specific Gravity and Surface Tension.

Prof. MacGregor[1] has proposed, in the case of simple solutions of electrolytes, so dilute that the ions and the undissociated molecules may be regarded as without mutual action, to express any of their physical properties, such as specific gravity, surface tension, &c., by the following formula:

$$P = P_w + k\,(1-\alpha)\,n + l\,\alpha\,n,$$

where P is the numerical value of the property for the solution, P_w that of the same property for water under the same physical conditions, n the concentration expressed in gramme-equivalents per unit volume, α the ionization coefficient of the electrolyte in the solution, and k and l constants, called ionization constants.

He has also shown how to predict the value of any such property for a mixture of simple solutions, by the aid of the ionization constants determined for the simple solutions.[2]

---

[1] Trans. N. S. Inst. Sci., 9, 219, 1896.

[2] *Note by the communicator of the paper.*—The fact that values of k and l in the above formula can be found which make the formula represent the observed values of a property for simple solutions of an electrolyte has of course little theoretical interest. The ionization coefficient, a, is a complex function of the concentration, n. If expressed in terms of powers of n the expression would involve several powers. (See Trans. N. S. I. S., 9, 112). The above expression for P is thus equivalent to an expression in terms of three or more powers of n with coefficients which are functions of constants determined by the electrical character of the electrolyte and of two additional arbitrary constants. As the concentration curves of specific gravity and surface tension for solutions are but slightly curved, it is thus to be expected that the above expression would represent them. It *is* of theoretical interest, however, to find whether, when the ionization constants for any property have been determined for simple solutions of two electrolytes, it is possible to predict the value of the property for mixtures by the method referred to. For (1) there are no arbitrary constants in the expression by which the prediction is made, (2) the expression itself is derived from the dissociation theory, and (3) the ionization coefficients of the electrolytes in the mixture, involved in the expression, are determined by a direct application of that theory. I think it well to make this remark because several reviewers of former papers have written under the apprehension that the k's and l's of the expression for the value of a property for a mixture (see p. 65 of this paper) were arbitrary constants determined by the observations on the mixtures. They are, however, the ionization constants already determined by observations on simple solutions. J. G. M.

In what follows I endeavor to ascertain whether or not the above formula is applicable to the specific gravity and surfaec tension of simple solutions of KCl and K_2SO_4 and whether or not it is possible to predict the values of these properties for mixtures of such solutions.

The observations of specific gravity requisite for this purpose were made by the writer in the way described above.

On surface tension Rother's observations were used. They were made at 15°C and his values are therefore not strictly comparable with calculated values based on ionization coefficients for 18°C. I have, however, reduced a few of the ionization coefficients of the salts to 15°C, by using [1]temperature coefficients, and found that the difference between the values for the two different temperatures is not sufficient to cause any appreciable error in my calculated results. Rother's paper has sufficient data for determining the concentration in gramme-equivalents per litre, with atomic weights as used in Table I. Rother regards his observations as possibly in error by +5 to +8 in the third place of decimals. The surface tension of the water he used was 7.357.

The following table, VI, contains the ionization coefficients for simple solutions, used in the calculations. They were obtained either from direct observations on the conductivity of the solution or by interpolation of the results of Tables I—III. The concentrations are expressed in gramme-equivalents per litre at 18°C.

---

[1]Kohl. u. Holb., *loc. cit.*, pp. 195-199, Table 7.

TABLE VI.

K Cl.		½ K_2SO_4.	
Concentration.	Ionization Coefficient.	Concentration.	Ionization Coefficient.
.01018	.932	.0517	.756
.05412	.880	.1035	.710
09454	.854	.2098	.666
.2185	.817	.2999	.626
.3400	.794	.3209	.617
.4941	.780	.3853	.603
.6851	.769	.4277	.594
.9558	.749	.5817	.569
1.046	.743	.5998	.566
1.085	.742	.7047	.558
1.428	.723	.7707	.549
2.138	.705	.8000	.545
		1.2125	.526

Determination of the Ionization Constants.

The values of the ionization constants (k and l) for either property of either salt were found by the method of least squares from the data of Tables VII and VIII for the four weakest solutions, for the specific gravity and surface tension respectively. The values thus found were employed in calculating the values of the properties of the various mixtures.

Results of the Calculations on Simple Solutions.

Tables VII and VIII contain the results of the calculations from the above formula for the two properties.

The concentrations are expressed as in the tables above.

TABLE VII.

Specific Gravity at 18° C. referred to Water at 18° C.

K Cl. k=.045775, l=.048251.				$\frac{1}{2}$ K_2SO_4. k=.062911. l=073959.			
Concentration.	Observed Value.	Calculated Value.	Difference.	Concentration.	Observed Value.	Calculated Value.	Difference.
.01018	1.00045	1.00049	$+0.0_44$	.0517	1.00374	1.00369	-0.0_45
.05412	1.00259	1.00259	$\pm0.0_40$	.1035	1.00731	1.00732	$+0.0_41$
.09454	1.00452	1.00454	$+0.0_42$	.2999	1.02088	1.02093	$+0.0_45$
.2185	1.01045	1.01044	-0.0_41	.3853	1.02683	1.02680	-0.0_43
.4941	1.02351	1.02357	$+0.0_46$	.5998	1.04097	1.04149	$+0.0_35$
.9558	1.04453	1.04554	$+0.0_21$	.7707	1.05266	1.05457	$+0.0_22$
1.085	1.05066	1.05166	$+0.0_21$				

TABLE VIII.

Surface Tension at 15° C.

K Cl. k=.25067. l=.12272.				$\frac{1}{2}$ K_2SO_4. k=.12302. l=.15919.			
Concentration.	Observed Value.	Calculated Value	Difference.	Concentration.	Observed Value.	Calculated Value.	Difference.
.3400	7.411	7.408	—0.003	.2098	7.389	7.388	—0.001
.6851	7.460	7.461	+0.001	.3209	7.402	7.404	+0.002
1.0459	7.518	7.520	+0.002	.4277	7.419	7.419	±0.000
1.4280	7.584	7.583	—0.001	.5817	7.441	7.440	—0.001
2.1829	7.705	7.707	+0.002	.7047	7.458	7.458	±0.000
				.8000	7.459	7.471	+0.012
				1.2125	7.529	7.529	±0.000

From Table VII it seems that the specific gravity of solutions of these salts between the concentration of about 0.01 and 0.5 can be calculated by aid of the formula and with the values of k and l given, while for surface tension (Table VIII) the calculation seems possible from a concentration of 0.2 to 1.0.

Mixtures of Solutions.

For a solution containing two salts, the equation for the value of a property, if there is no change of volume on mixing, is of the form

$$P = P_w + (k_1(1-\alpha_1)n_1 + l_1\alpha_1 n_1)\frac{v_1}{v_1+v_2} + (k_2(1-\alpha_2)n_2 + l_2\alpha_2 n_2)\frac{v_2}{v_1+v_2},$$

where the n's are the concentrations of the constituent solutions, the α's the ionization coefficients of the respective electrolytes in the mixture, and the v's the volumes of the constituent solutions, the electrolytes being indicated by 1 and 2.

The ionization coefficients of the salts in the mixture are obtained by the before-mentioned graphical method from the same curves as were used in the conductivity determinations for mixtures of solutions of these salts. The k's and l's are the ionization constants obtained for the simple solutions, and given in Tables VII and VIII.

For the specific gravity measurements, equal volumes of the constituent solutions were mixed; while Rother mixed equal weights of the simple solutions. He, however, gives sufficient data for the calculation of the concentration and volume of the constituent solutions.

The following table contains the requisite data for determining the values of the two properties from the above equation, and also, for the comparison of the results thus calculated with the observed values. The volumes of the constituent solutions in Table X, are expressed in litres at 18°C. The concentrations are expressed as in the former tables.

TABLE IX.

SPECIFIC GRAVITY AT 18° C. REFERRED TO WATER AT 18° C.

Concentration of Constituent Solutions.		Ionization Coefficients in Mixture.		Observed Value.	Calculated Value.	Difference.
$\frac{1}{2}K_2SO_4$.	K Cl.	$\frac{1}{2}K_2SO_4$.	K Cl.			
.1035	.01018	.750	.879	1.00389	1.00393	$+0.0_4\,4$
"	.05412	.721	.874	1.00497	1.00496	$-0.0_4\,1$
.7707	.09454	.586	.800	1.02899	1.02899	$\pm0.0_4\,0$
.5998	.9558	.533	.766	1.04271	1.04341	$+0.0_3\,7$

TABLE X.

SURFACE TENSION AT 15° C.

Constituent Solutions.				Ionization Coefficients in Mixture.		Observed Value.	Calculated Value.	Difference.
Concentration.		Volume.						
$\frac{1}{2}K_2SO_4$.	K Cl.	$\frac{1}{2}K_2SO_4$.	K Cl.	$\frac{1}{2}K_2SO_4$.	K Cl.			
.7243	.2718	.49124	.50902	.581	.769	7.438	7.435	−0.003
.2423	.7483	.50535	.49466	.569	.788	7.447	7.430	−0.017
.8917	.6869	.49330	.50693	.535	.763	7.471	7.475	+0.004
.4921	1.7115	.51100	.48989	.470	.742	7.527	7.529	+0.002
1.1936	1.4158	.49646	.50354	.445	.740	7.554	7.550	−0.004

According to Table IX it appears that the specific gravity of a solution of these salts from an average concentration of about 0.05 to 0.5 can be calculated by the above formula, and with the above values of the ionization constants.

From Table X this formula applies for surface tension of solutions of these salts from a concentration of 0.5 to 1.3.

Summary of Results.

According to the above results it is possible, by the aid of the dissociation theory and with data obtained from the simple solutions, to predict the conductivity, specific gravity and surface tension, of fairly dilute solutions of potassium chloride and potassium sulphate, within the limit of experimental error.

IV.—On finding the Ionization of Complex Solutions of given Concentration, and the Converse Problem: *By* Prof. J. G. MacGregor, *Dalhousie College, Halifax, N.S.*

(Received September 30th, 1899.)

In a paper communicated to this Institute in 1895,[1] I described a method of determining the ionization coefficients of two electrolytes, with one ion in common, in the same dilute aqueous solution. The method described was developed in the study of complex solutions which had been formed by the mixture of simple solutions of known concentration, and involves a knowledge of their concentrations. Even if the complex solutions have not been formed in this way, but have been prepared, say, by the addition of known quantities of the electrolytes to a known quantity of water, they may always be imagined to have been formed by mixture of simple solutions; and in the usual case in which the solutions are so dilute that no change of volume would have occurred in forming them by mixture, the concentrations of the simple solutions by the mixing of which the given complex solution might be formed, can readily be determined. But a simple modification of the method renders it applicable in such cases directly; and when so modified, its application is found both to require fewer data with respect to the conductivity of simple solutions of the electrolytes involved, and to be subject to fewer sources of error, than in its old form. As modified also, it is found to be readily applicable conversely to the determination of the concentration which such complex solutions must have in order that they may have any given possible state of ionization.

In the present paper, I wish to describe this modified form of the method, and to point out how it may be used in deter-

[1] Trans. N. S. Inst. Sci., 9, 101, 1895-96: See also Phil. Mag. (5), 41, 276, 1896, and Trans. Roy. Soc. Can., (2), 2, sec. 3, 65, 1896-7.

mining concentration when state of ionization is given. And I take this opportunity also, of comparing it with two other methods which have recently been employed, of determining the ionization coefficients for solutions of the same degree of complexity.

Determination of the ionization, concentrations being given.

It was shown in the papers cited above, that if the two electrolytes in a complex solution may be supposed to occupy distinct portions or regions of the solution, if the law of kinetic equilibrium may be supposed to be applicable both to these regions singly and to the whole volume of the solution, and if the concentration of ions of each electrolyte in its own region may be supposed to depend at a given temperature on the dilution of the electrolyte in its region, merely, and to depend on dilution in the same way as in the case of a simple solution of the same electrolyte, the relations between the ionization coefficients, the amounts of the electrolytes present, and the dilutions which they must be supposed to have in their fictitious regions, may be expressed by four equations. If we denote the electrolytes by 1 and 2, the concentrations (in gramme-equivalents per litre) of the solution with respect to them by N_1 and N_2 respectively, their ionization coefficients by a_1 and a_2 and their regional dilutions (in litres per gramme-equivalent) by V_1 and V_2 respectively, these equations take the form:

$$\frac{a_1}{V_1} = \frac{a_2}{V_2}, \qquad . \quad . \quad . \quad . \quad (1)$$

$$N_1V_1 + N_2V_2 = 1, \qquad . \quad . \quad . \quad . \quad (2)$$

$$\frac{a_1}{V_1} = f_1(V_1), \qquad . \quad . \quad . \quad (3)$$

$$\frac{a_2}{V_2} = f_2(V_2), \qquad . \quad . \quad . \quad . \quad (4)$$

the functions f_1 and f_2 being determinable by means of sufficiently extended observations of the conductivity of simple solutions of 1 and 2 respectively.

The first equation is given by the law of kinetic equilibrium. It may be expressed as follows: The regional ionic concentrations of the two electrolytes, *i. e*, the numbers of their free gramme-ions per unit volume of their respective regions, are equal. The second states that the volume of the solution is equal to the sum of the volumes of the regions of the respective electrolytes. The third and fourth assert that the regional ionic concentrations are functions of the respective regional dilutions.

As f_1 and f_2 are very complex functions, these equations could not be solved algebraically even if the functions were known. They can be solved graphically, however, without actually determining what the functions are.

For this purpose we first find, from conductivity observations made on simple solutions of 1 and 2 respectively, corresponding values of dilution and ionic concentration for a sufficient number of solutions of each, and plot dilution-ionic-concentration curves, *i. e.*, curves with dilutions as ordinates and ionic-concentrations as abscissæ. To get precise values of the ionization coefficients for the complex solutions, these curves must be accurately drawn. They have, very roughly speaking, the shape of rectangular hyperbolas, and thus, both at great dilution and at great concentration, have but slight curvature, while at moderate dilution they have very rapid curvature. In working with solutions at moderate dilution therefore, it is necessary to have a considerable number of corresponding values of dilution and ionic concentration, in order to plot the curves accurately. When but few are available, it is helpful to plot first a concentration-ionic-concentration curve, *i. e.*, one having concentrations of solutions as ordinates and ionic-concentrations as abscissæ. As the dilution-ionic-concentration curves are something like rectangular hyperbolas, the concentration-ionic-concentration curves have comparatively slight curvature, and thus lend themselves readily to interpolation. Corresponding values of concentration and ionic concentration obtained from these curves, when the concentrations are transformed into dilutions, may be used to eke out the values

obtained from the few available observations. In some cases also Kohlrausch's[1] observation may be utilised, viz., that the curves obtained by plotting equivalent conductivity against linear concentration (*i.e.*, the cube root of the concentration), are for univalent salts, through considerable ranges, practically rectilinear.

The dilution-ionic-concentration curves, having been drawn for the simple solutions (curve A for electrolyte 1, and B for 2, in the figures below), the problem resolve itself into finding two points, one on each curve, having, according to equation (1), the same abscissa, and having ordinates which satisfy the condition of equation (2). This may be done of course by inspection, but more accurately, and usually more quickly, by one or other of several graphical processes.

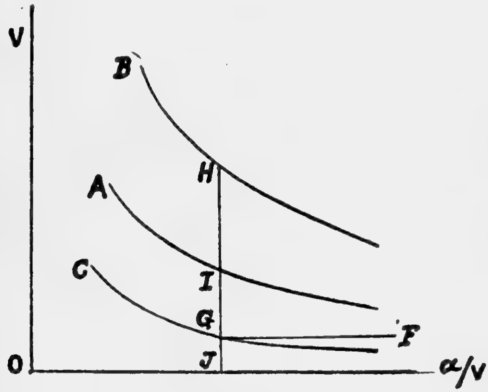


Fig. 1.

(1.) Plot a new curve C (Fig. 1) with the same abscissæ as A and B, but with ordinates equal to the sum of N_1 times the ordinates of A and N_2 times the ordinates of B. Then draw the straight line F G parallel to the axis of ionic concentrations and at a distance unity from it (I assume for simplicity that the dilutions and ionic concentrations have been plotted to the scale unity). Let F G cut C in G; and through G draw the straight line G J parallel to the axis of dilutions and cutting A and B in I and H respectively. I and H are the two points required. For they have the same abscissa O J, and their ordinates, I J and H J, are such that

$$N_1 \, . \, IJ + N_2 \, . \, HJ = GJ = 1.$$

Then $$a_1 = OJ \, . \, IJ, \text{ and } a_2 = OJ \, . \, HJ.$$

[1] Wied. Ann., 26, 201, 1885.

(2.) As equation (2) may be written:

$$V_1 + \frac{N_2}{N_1} V_2 = \frac{1}{N_1},$$

we may proceed as follows:—

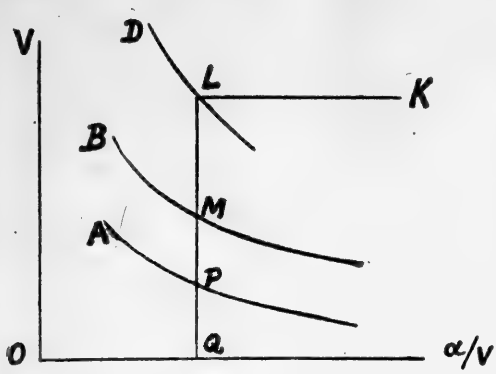


Fig. 2.

Plot a new curve D (Fig. 2) with the same abscissæ as A and B, but with ordinates equal to the sum of the ordinates of A and N_2/N_1 times the ordinates of B. Draw K L parallel to the ionic-concentration axis and at a distance $1/N_1$ from it, and let it cut D in L. Draw L Q parallel to the dilution axis and cutting A and B in P and M respectively. P and M are the two points required. For they have the same abscissa O Q, and their ordinates, P Q and M Q, are such that

$$PQ + \frac{N_2}{N_1} MQ = LQ = \frac{1}{N_1}.$$

Then $\qquad a_1 = OQ . PQ$, and $a_2 = OQ . MQ$.

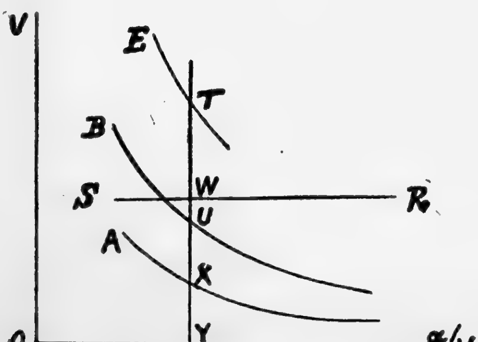


Fig. 3.

(3) Plot a new curve E (Fig 3), having the same abscissæ as A and B, but with ordinates equal to N_2/N_1 times the ordinates of B. Draw R S parallel to the axis of ionic concentrations and at a distance from it of $1/(2\,N_1)$. Find, by inspection, the line T Y parallel to the axis of

dilutions, of which the intercept T X, between the curves A and E, is bisected by R S, W being the point of bi-section. Let T Y cut B in U. X and U are the points required. For they have the same abscissa O Y, and their ordinates, X Y and U Y, are such that

$$XY + \frac{N_2}{N_1} UY = 2WY = \frac{1}{N_1}.$$

Then $$a_1 = OY.\ XY, \text{ and } a_2 = OY.\ UY.$$

The second and third of these methods involve less arithmetical work, and are less liable to error, than the first, and the second does not require the procedure by inspection which is required by the third. The second is therefore the most satisfactory. But the limited area of co-ordinate paper frequently gives the third a practical advantage.

Only such portions of the curves A, B, C, D, E, need be drawn of course as may be seen by inspection to be required for the purpose in hand.

Determination of the concentration, when the required ionization is given.

The determination of the concentration which must be given a complex solution in order that it may have any required state of ionization, is of importance as facilitating the conducting of research based on the dissociation theory of electrolysis.

It is not sufficient for the determination of the concentration which the solution must have with respect to the two electrolytes, that the required ionization coefficients a_1 and a_2 should be given, because they are not independent. For a given value of a_1 the regional ionic concentration of electrolyte 1 has a determinate value, which may be found by plotting a curve for simple solutions of 1, with ionization coefficients as ordinates and ionic concentrations as abscissæ. The regional ionic concentration of electrolyte 2, must by equation (1) be the same as that of electrolyte 1; and since it is thus determined, the ionization coefficient, a_2, can have but one value which may be found by the aid of an ionization-coefficient-ionic-concentration curve

for electrolyte 2. Thus any one of the quantities a_1, a_2, and the common regional ionic concentration, which is of course equal to the total ionic concentration of the whole solution, being given, the others may be found, if we have sufficient data as to the conductivity of the simple solutions.

Even if the ratio only of the ionization coefficients is given, the state of ionization is in many cases completely determined. For as

$$\frac{a_1}{V_1} = \frac{a_2}{V_2},$$

we have

$$\frac{a_1}{a_2} = \frac{V_1}{V_2},$$

and the dilution-ionic-concentration curves are frequently of such forms that a given value of V_1/V_2 corresponds to a definite value of V_1 and V_2, which may be found by inspection of the curves.

Some datum in addition to the state of ionization is therefore requisite, if the concentration of the solution is to be fully determined. It may be the concentration with respect to one of the electrolytes, or the ratio of the concentrations with respect to the two, or the total concentration, or any such function (the conductivity for example) of the concentrations with respect to the two. If the state of ionization is not fully given, an additional datum is obviously required.

(1.) Given the required state of ionization and the concentration with respect to one electrolyte : to find the concentration with respect to the other.—A and B (Fig. 3) being the dilution-ionic-concentration curves, O Y is given ; and N_1 being also given, we have only to find N_2/N_1 in order to determine N_2. From Y draw Y T parallel to the dilution-axis, cutting A and B in X and U respectively. Draw the line R S parallel to the axis of ionic concentrations and distant from it by $1/(2\,N_1)$. Let R S cut Y T in W. Cut off W T equal to X W. Then TY/UY will be the value of N_2/N_1. (The curve E in Fig. 3 is of course not required.)

(2.) Given the required state of ionization and the ratio of

the concentrations with respect to the two electrolytes: to find the concentrations.—As before, O Y (Fig. 3) is given. From Y draw Y T parallel to the dilution axis, making it of such length that T Y/U Y is equal to the given ratio of the concentrations N_2/N_1. Bisect X T in W. Then

$$W Y = \frac{1}{2N_1}, \text{ and } N_1 = \frac{1}{2\,WY}.$$

N_2 also may therefore be found.

(3.) Given the required state of ionization and the total concentration $(N_1 + N_2)$ or the difference of the concentrations $(N_1 - N_2)$: to find N_1 and N_2.—The state of ionization being given, not only are a_1 and a_2 known, but also the total ionic concentration, $a_1 N_1 + a_2 N_2$, which is equal to the regional ionic concentration common to the two electrolytes. N_1 and N_2 may therefore be determined.

(4.) Given the required state of ionization in a solution which is to have a given conductivity: to find the concentrations N_1 and N_2.—As in (3), a_1, a_2, and $a_1 N_1 + a_2 N_2$ are known. The conductivity is expressed by the equation:

$$k = a_1 N_1 \mu_{\infty 1} + a_2 N_2 \mu_{\infty 2},$$

the μ_∞'s being the equivalent conductivities, at infinite dilution, of simple solutions of 1 and 2, and being thus known. N_1 and N_2 may therefore be determined.

Other methods of determining the ionization for complex solutions.

(1.) Schrader[1] has attempted to determine the ionization coefficients for solutions containing two electrolytes with a common ion, by a combination of observations of their conductivity and their electrolysis. The expression of the dissociation theory for the conductivity of such a solution may be put into the form:

$$k = a_1 N_1 \mu_{\infty 1} \left(1 + \frac{a_2 N_2 \mu_{\infty 2}}{a_1 N_1 \mu_{\infty 1}}\right) = a_2 N_2 \mu_{\infty 2} \left(1 + \frac{a_1 N_1 \mu_{\infty 1}}{a_2 N_2 \mu_{\infty 2}}\right).$$

[1] Zur Elektrolyse von Gemischen, Inaug. Diss., Berlin, 1897.

As $a_1 N_1$ and $a_2 N_2$ are the numbers of gramme-equivalents of dissociated molecules of (1) and (2) respectively in unit volume of the solution, and as $\mu_{\infty 1}$ and $\mu_{\infty 2}$, the respective equivalent conductivities at infinite dilution, of simple solutions of 1 and 2, may in sufficiently dilute solutions, whether simple or complex, be regarded as equal to the velocity of either ion, relative to the other, of 1 and 2 respectively, the quantity $a_2 N_2 \mu_{\infty 2} / a_1 N_1 \mu_{\infty 1}$ may be taken to be the ratio of the number of gramme-ions of 2 and 1 separating out primarily at the appropriate electrode, during electrolysis. This ratio Schrader determined by electrolytic observations. Calling it x, we have :

$$a_1 = \frac{k}{N_1 \mu_{\infty 1} (1 + x)},$$

$$a_2 = \frac{kx}{N_2 \mu_{\infty 2} (1 + x)}.$$

The values of the ionization coefficients obtained in this way are affected not only by the error involved in the measurement of conductivity, but by the more serious error involved in electrolytic determinations. They cannot be expected therefore to have any high degree of precision.

While Schrader determined the ionization coefficients for solutions containing potassium chloride and iodide, and hydrogen and copper sulphates, and drew certain conclusions from their relative magnitudes in each case, he made no attempt to test the values obtained. They cannot of course be tested by applying them to the calculation of the conductivity of the solutions or the results of their electrolysis ; for these have been used as data in their determination. But they may be tested by being compared with the values given by the method described above. For the values given by this method have stood the test of application to the calculation of the conductivity[1], results of

[1] MacGregor: Trans. N. S Inst. Sci., 9, 101, 1895-6.
McIntosh: *Ibid.* 9, 120, 1895-96.
Archibald: *Ibid.* 9, 291 and 307, 1897-98; and Trans. Roy. Soc. Can., (2), 3, sec. 3, 69, 1897-98.
McKay: Trans. N. S. Inst. Sci., 9, 321 and 348, 1897-98.
Barnes: *Ibid.*, 10, 49, 1898-99.

electrolysis[1], lowering of the freezing point[2], specific gravity and other physical[3] properties, of complex solutions, in all cases in which the attempt has been made, except in the case of Schrader's solutions containing copper sulphate and sulphuric acid, in which there can be little doubt that the acid sulphate had formed. In the case of Schrader's solutions of potassium iodide and chloride, his observations of conductivity and his electrolytic observations have been shown to be consistent with calculability though they are not sufficiently precise to demonstrate it. We may thus fairly test Schrader's electrolytically determined ionization coefficients by comparing them with those obtained by the above method.

I have accordingly determined the coefficients for the four solutions examined by him, and they are given in the following table. In determining them I have used Kohlrausch's observations of the conductivity of simple solutions, and as the equivalent conductivities at infinite dilution, not Kohlrausch's most recent determinations, but those employed by Schrader. As Schrader does not state at what temperature he made his observations, he may be supposed to have made them at ordinary laboratory temperature, which is not far removed from Kohlrausch's temperature, 18° C.

Concentration (gr.-eq. per litre) with respect to		IONIZATION COEFFICIENTS.					
		SCHRADER'S.		MINE.		Difference per cent.	
K I.	K Cl.	K I.	K Cl.	K I.	K Cl.	K I.	K Cl.
.02595	.02571	.857	.868	.915	.897	−6.3	−3.2
.03442	.04748	.866	.892	.886	.866	−2.3	+3.0
.03074	.06176	.861	.857	.879	.860	−2.0	−0.3
.01992	.03720	.819	.901	.907	.890	−9.7	+1.2

[1] MacGregor: Trans. Roy. Soc. Can., (2). 4, sec. 3, 117, 1898-99.

[2] Archibald: Trans. N. S. Inst. Sci, 10, 33, 1898-99.

[3] MacGregor: *Ibid.* 9, 219, 1896-97.
Archibald: *Ibid.*, 9, 335, 1897-98.
Barnes: *loc. cit.*

It will thus be seen that Schrader's coefficients differ from mine by various amounts up to about 10 per cent., being in most cases smaller, but in some greater. It should be noted also, that while my coefficients are in all cases greater for the iodide than for the chloride, Schrader's are in three out of four cases greater for the chloride than the iodide.

(2) Kay[1] has recently employed an approximation method based upon one previously used by Arrhenius. As a first approximation the ionization coefficients of the two electrolytes in a complex solution were assumed to be the same as they would be in simple solutions of concentration equal to the total concentration of the complex solution. The total concentration of ions of the complex solution (equal to the regional ionic concentrations of the respective electrolytes) was then calculated, and gave a first approximation to the value of the regional ionic concentration. From curves plotted with ionization coefficients of simple solutions as ordinates and ionic concentrations of the same solutions as abscissæ, the values of the ionization coefficients corresponding to the first approximation to the regional ionic concentrations were read off and formed second approximations to the ionization coefficients required. Calculation of the second approximation to the total ionic concentration and a repetition of the above procedure gave a third approximation to the ionization coefficients. In dealing with solutions containing sulphuric acid and a neutral sulphate, he found that in general the second approximation was so close to the first that a third was not necessary; and he seems to have found that the third in no case differed appreciably from the second.

As, in the case of electrolytes with a common ion, the variation of ionization with dilution is in general not very different, this method may be expected to give very closely approximate results. By way of a test I have made a few determinations for solutions containing zinc and potassium sulphates, using Kohlrausch's conductivity data. The result is shown in the following table in which zinc sulphate is indicated by 1 and

[1] Proc. R. S. Edin., 22, 502, 1898-99.

potassium sulphate by 2, concentration in gramme-equivalents per litre by N, and ionization coefficient by a.

N_1	N_2	By Kay's Method.								By my Method.	
		1st Approx.		2nd Approx.		3rd Approx.		4th Approx.			
		a_1	a_2	a_1	a_2	a_1	a_2	a_1	a_2	a_1	a_2
.01	.03	.509	.799	.469	.807	.470	.808	....	....	.469	.807
.01	.04	.457	.759	.407	.766	.408	.767	....	....	.404	.777
.002	.2	.342	.658	.281	.658	.282	.658	....	....	.280	.659
.2	.002	.342	.658	.341	.712	.341	.712	....	....	.341	.712
.4	.1	.276	.583	.259	.636	.260	.637	.260	.636	.256	.639

The above table shows that for the solutions to which it applies, the ionization coefficients given by Kay's method agree closely with those given by mine, the differences being in no case greater than a little over 1 per cent., and in most cases a small fraction of 1 per cent. It is worth noting that in the cases in which a difference exists, the second approximation values of Kay's method are in general less divergent from mine than those given by higher approximations.

If Kay's method involved considerably less labour than mine it would be worth while to carry out a more extensive comparison in order to determine its general trustworthiness. But the saving of labour, after a little practice with my method, is so slight, that such a comparison is uncalled for. In cases in which either the available data do not admit of the determination of precise values of the ionization coefficients or only approximate values are desired, sufficiently good values may be obtained, with somewhat less trouble, by the use of Kay's method. But in cases in which precise values are desired, and the data are sufficiently exact to give them, the more exact method is to be preferred, notwithstanding the slightly greater labour which it involves.

V.—New Mineral Discoveries in Nova Scotia.—By Edwin Gilpin, Jr., A. M., Ll. D., F. R. S. C., *Inspector of Mines, Halifax, N. S.*

(Read 13th March, 1899.)

The early operations in mining, metallurgy, engineering, etc., were much more simple than those of the present day. They were based of course upon the same general principles that underlie them to-day. The difference, however, in exactness and precision have permitted of vastly greater and cheaper productions. In smelting iron ore, for instance, the composition, weight, and relative proportions of the fluxes, fuels, and ores, are calculated to a nicety, so that the analysis and composition of the resulting pig iron can be safely predicted. The direct outcome of the application of exactness is the opportunity for increasing and cheapening productions. The day of the rule of thumb has passed in iron making as well as in other metallurgical processes.

In this Province we are to some extent interested in iron ore, but at present the adaptability of our coals for coke making is a subject of much enquiry. For many years coal was made into coke by burning off its volatile ingredients in round ovens, resembling bee hives, with more or less admission of air. The matter driven off somewhat resembled in composition the gas made in gas works, and contained a large amount of combustible matter. The illuminating gas made in gas works was produced from retorts into which no air was admitted during the operation of heating. The problem was the production of coke in ovens, on a large scale, equal to that used in the blast furnace, and at the same time to secure the largest amount of gas, or volatile matter, from the coking coal, with as little deterioration as possible from the admission of the nitrogen bearing atmosphere.

This problem has been gradually solved, and now it is possible to produce a good coke, on a commercial basis, and at the same time to save large volumes of gas adapted for illuminating and heating purposes. No doubt many improvements remain to be introduced.

The works of the Halifax Gas Company, at the North-West Arm, are the first established on this side of the Atlantic to carry out this principle, which has already been practised at several places in Europe. The experience gained here has led to the establishment of an enormous plant on similar lines, to supply gas in Boston. The result of this enterprise is being watched with much interest in the United States, and its success will lead to the establishment of similar plants at many commercial centres. The application of gas in that country for engine power, and many other uses, was no doubt largely due to the supply of natural gas available for many years. The gradual decrease of natural gas excites interest in any scheme proposed to fill its place.

The proposal to utilize Cape Breton coal in the new works at Boston led to a number of tests of the coal as to its gas, coke values, etc., as well as to the quantity and nature of the impurities present. This evening I propose to give briefly some results arrived at, that they may be on record for comparison with future tests. I have also a few remarks on new discoveries of ores in Nova Scotia.

At the Halifax works, the coal used is washed slack from the Phalen and Harbor seams, of the Dominion Coal Company, approximating 60 per cent of fixed carbon. The gas is divided into that available for illuminating purposes, and the poorer gas to be used for heating the ovens, and for sale for heating purposes. In 24 hours, 37 short tons yield 310,000 cubic feet of gas, of which 100,000 cu. ft., 32.26 per cent, are illuminating gas, and 210,000 cu. ft., 67.74 per cent, heating gas; of the latter 170,000 cu. ft. are consumed in the process of coking, and the balance 40,000 cu. ft. can be used as heating gas. A long ton furnishes, on the average, 5 lbs. ammonia gas, and 12 gallons,

120 lbs., of tar. The ammonia liquor is distilled with milk of lime, and furnishes a shipping ammonia liquor with 17 per cent ammonia. The tar is available for distillation for creasote, pitch, etc. Finally the coke, forming 75 per cent of the coking charge, is available as a very excellent fuel. No doubt these results will be improved on.

More interesting information is given by a test made of the Harbor seam at the Glassport, Pa., ovens of the United Coke and Gas Company. The coal used in these ovens was run of mine from the Upper Youghiogheny River, with the following composition: Moisture, 60; fixed carbon, 59.18; volatile matter, 33.01; ash, 7.21; phosphorus, .0071; total sulphur, 1.27. The resulting coke, 74.26 per cent, had the following composition:— Volatile matter, 1.00; carbon, 86.47; ash, 11.57; sulphur, .96; phosphorus, .0107. A net ton furnishes 10,000 cubic feet of gas, of which 70 per cent is used for heating the ovens, and the remainder is piped to steel works.

The coal from the Harbor seam was slack, washed in Cape Breton, and at the time of coking contained as much as 9 per cent of moisture, as the cars stood for some months exposed to winter weather. As under normal conditions this percentage would be very much less, allowances should be made for purposes of comparison.

An average of several analyses gave the following as the composition of the coal:—

Carbon	75.10
Hydrogen	3.75
Nitrogen	1.51
Oxygen, Sulphur	13.80
Ash	5.84
	100.00
Volatile matter	34.60
Fixed Carbon	59.56
Ash	5.84
	100.00

In the destructive distillation of coal the sulphur is divided between the gas and the coke. From the former it can be removed by increasing the purification plant, but its removal from the latter is still practically an unsolved problem. It may be said in general terms that about half the sulphur is usually driven from the coal in the coking process.

As the sulphur in the coke is largely transmitted to the pig iron made in a blast furnace, its presence in any large amount is a serious matter. As yet, attempts to lessen the amount of this impurity have been confined to taking advantage of its higher specific gravity, as compared with that of coal, to separate it more or less thoroughly by washing processes. In this connection some figures on the practical use of Cape Breton coke in the Ferrona furnace may be of interest. The percentage of sulphur in the coal may occasionally reach 3 per cent; again it runs down to a few tenths of 1 per cent. This difference exists between different layers of the same bed, and different localities in the same mine. The average percentage is low. The coke made from unwashed Dominion coal contains, as impurities, 1.08 per cent of sulphur, and 8.2 per cent of ash. Coals running higher in sulphur are washed before being coked. In the manufacture of Bessemer pig the amount of phosphorus in the coke is an important item. It is exceptionally low in this coke, averaging .0028 per cent. The calorific value of the dry fuel, containing 5.84 per cent of ash is, according to the Dulong-Mahler formula, 12.437, B. T. U. The coke is of good quality, hard and compact.

The pig iron has the following composition:—

	Basic pig.	Foundry pig.
Silicon	.50	2.32
Manganese	.87	.65
Phosphorus	1.23	1.20
Sulphur	.017	.02
G. Carbon	....	3.64
C. Carbon	....	.23
Iron	97.00	92.00

In an oven 18 inches wide, if the coke be not required for blast furnaces, the time of coking would be about 23 hours.

The following summary shows the results obtained per long ton from a series of charges coked under usual working conditions at Glassport :—

		Lbs.	Per cent.
Coke, total.	large coke >1″ — 66.69 p. cent; small " ½—1″ 1.64 "; dust " <½″ 2.80 "	1,593.4	71.13
Tar		75.7	3.38
Ammonia (1.373 per cent sulphate)		7.6	.34
Gas, total, 10,390 cu. ft. of .466 sp. gr.		368.0	16.43
Sulphur compounds in gas :—			
Hydrogen Sulphide		10.8	.48
Carbon Disulphide		1.6	.07
Gas Liquor and Loss, by difference		182.9	8.17
Totals		2,240.0	100.00

Of the gas produced, 49.5 per cent was " surplus " gas, that is, gas not required for heating the ovens. This had the following composition :—

Olefines, $C_m H_n$	5.2
Marsh gas, $C H_4$	38.7
Carbon monoxide, $C O$	6.1
Carbon dioxide, $C O_2$	3.6
Oxygen, O	.3
Nitrogen, N	7.7
Hydrogen, H	38.4
	100.0

Its calorific power, the hydrogen burnt to water, was 686 B. T. U., its candle power 14.7, and its specific gravity, .51. The coke contains in addition to the fixed carbon, volatile matter, 1.27 ; ash, 8.91 ; phosphorus, .0041 ; moisture, 3.67. The ash contains 27.71 per cent of silica, 13.04 per cent of aluminia, and 50.60 peroxide of iron, with small quantities of alkalies and alkaline earths.

The yield of tar per long ton was 75.7 lbs., or 3.38 per cent. The following table shows its behaviour under fractional distillation :—

Fractions.	Temperature. °C.	
Light oil	80-170	3.7
Middle oil	170-230	9.8
Heavy oil	230-270	12.0
Anthacine oil	over 270	4.3
Pitch		67.0
Water		2.3
Loss		.9

As the ultimate analysis shows 1.51 per cent. of nitrogen in the coal, and the .34 per cent. ammonia, 7.6 lbs. per long ton, in the gas liquor requires .28 per cent. nitrogen, it follows that 18.5 per cent. of the total nitrogen in the coal is converted into ammonia, instead of usually 13½ to 15 per cent.

Three periods may be observed during the process of coking, in the composition and value of the gases given off. At first the proportion of marsh gas (CH_4) is high but gradually lessens.

The following is the surplus gas produced during the first 14¾ hours :

Average calorific value	685.8	B. T. U.
Average illuminating value	14.7	C. P.
Volume per long ton	5143.	C. F.

The oven heating gas produced during the remaining 19 hours is as follows :

Average calorific value	566.7	B. T. U.
Average illuminating value	9.0	C. P.
Average per long ton.	5247.0	C. F.

The gas during the last few hours is very low in calorific and candle power, but owing to its carrying a large per cent. of hydrogen, it can after being purified, be enriched with benzole or oil vapors and be added to the first gas. Practically, however, the third gas is added to the oven heating gas, and the following table shows the composition of the two :—

	First, or Surplus Gas.	Second, or Oven Gas.	Average.
Olefines	5.2	2.4	3.8
Marsh Gas	38.7	29.2	33.9
Hydrogen	38.4	50.5	44.5
Carbon Monoxide	6.1	6.3	6.2
Carbon Dioxide	3.6	2.2	2.9
Oxygen	.3	.3	.3
Nitrogen	7.7	9.1	8.4
	100.0	100.0	100.0

The foregoing figures are interesting from a chemical standpoint, but no doubt as experience is gained the results will be modified and improved.

Oil shale in Cape Breton.

Experiments have been made recently on the oil values of some shale deposits in Cape Breton County, which may appropriately follow the notes on the distillation of Cape Breton coals. At Macadam's Lake, on the North side of East Bay, the lower carboniferous measures rest on silurian and precambrian strata. Here a number of beds of black lustrous shale are found associated with conglomerates, gray shales, and sandstones pitching heavily to the south, away from the older rocks. These black shales are so highly charged with carbonaceous matter as to be capable of combustion. Explorations have shown a number of beds of this character from two to ten feet in thickness, extending for several miles in an easterly and westerly direction.

The following results are stated to have been obtained from working tests. The distillation in retorts yields beside a little water, a quantity of heavy oil, a little gas, and coke available for fuel. The yield of oil is from 15 to 20 gallons per ton of 2000 lbs. In refining this crude distillate, the products may be divided into different varieties, according to the market. A convenient division yields 20 per cent kerosene, 20 per cent white spindle or sewing machine oil, 40 per cent heavy lubricating oil, and 20 per cent pitch.

The kerosene does not practically differ from ordinary American petroleum kerosene. It refines white and is very free burning. White Spindle oils are the most costly in the market. There are none, however, in the United States obtained from petroleum so white and so heavy as this from East Bay. The lubricating oil is heavy, while it is as light in color as the heaviest parafine oil in America. The yield of crude oil is found to be about 6.25 per cent, and the proportions per ton would be :—

Kerosene oil	1.25	per cent.
White Spindle oil	1.25	"
Heavy Lubricating oil	2.50	"
Pitch	1.25	"
Water	5.75	"
Coke	87.50	"
Loss, gas, etc.	.50	"
	100.00	

It is also ascertained that this material is readily distilled and refined by methods and apparatus in general use in shale and petroleum industries in Great Britain and the United States. The pitch is of good quality.

If these statements are verified by actual practice, and the costs permit, a large and important industry may be counted on here. Should these oils find a market and demand abroad, no doubt the shales in various parts of the province, known to be bituminous, will receive attention.

Iron Ore.

The district lying between little Bras d'Or and East Bay in Cape Breton County is traversed diagonally by lower silurian strata and by the felsitic and limestone divisions of the pre-cambrian, which are flanked by lower carboniferous strata. The presence of iron ore near the junction of the George's River limestone and lower carboniferous has long been known near Gillies' Lake, and outcrops are known at Upper French Vale

and near the mouth of the Barasois River, emptying into the Little Bras d'Or. At the latter place the silurian slates are literally soaked in iron oxide, and at several points they present deposits which may on further investigation prove of economic value.

To the south-west of the railway bridge at Barasois, on a line running towards Eskasonie on East Bay, are several large outcrops of magnetite. As yet little work has been done to test the value of these deposits. Should these deposits prove to be free from titanic acid, they should, judging from the following analysis, be available for the operations of the miner :—

Oxide of Manganese and Alumina	.60
Lime	.11
Magnesia	.10
Sulphur	.05
Phosphoric Acid	.04
Silica	2.12
Volatile	.84
Metallic Iron	67.298

The question of the amount, quality, and cheapness of iron ore is one of the great problems of the day. The United States are exceptionally fortunate in having in its North-Western States what may be termed the greatest deposits of Bessemer ore yet discovered. The size of these deposits, their purity, their accessibility, and the lavish expenditure for their cheap mining and transportation have combined to build up at Chicago, Pittsburg, and other points, the greatest individual steel works of the world. Without the iron ores of Michigan, the United States would to-day occupy a position much less menacing to the commercial destinies of England and the Continent. It is true that the competition England has had hitherto to meet in the iron industry has come chiefly from the pig iron of Tennessee, but this can be largely met by the English furnace masters building larger furnaces and securing lower local railway freights. Although these precious deposits, more valuable than gold and silver mines, were heralded as everlasting already their exhaustion is a question of not many years, as new dis-

coveries are seldom announced. Already the vast iron ore deposits on the Canadian side of the great lakes are engaging the attention of the more far-seeing of the United States iron masters At present these deposits are not available. England, France and Germany draw large supplies of Bessemer ore from Spain and Algiers, This source now shows signs of weakening, and the magnetic ores of Sweden and Norway are gradually being drawn upon in amounts annually increasing.

There is no known geological reason why Labrador, Newfoundland, and Cape Breton should not contribute to this demand, ever increasing and never satisfied. The existence of iron ore at many points in Cape Breton is already known. The attempts made to find deposits, and to test them are scarce worth noticing. In the forest and swamp-covered tracts there may be masses of iron ore worth an empire's ransom.

It must, however, be remembered that these deposits, to be of any value, must be pure, extensive, and capable of cheap mining and shipping. The output must be large and the expenses low to enable the Cape Bretoner to enter into the world's competition in selling iron ore in the markets of the world.

Wolframite.

Last spring a discovery of this mineral was made at North-East Margaree, Inverness County. Full particulars of this deposit are not yet available. It is stated to occur in a vein, in places three feet wide, and to be present in amounts permitting readily of concentration to a high percentage. The mineral is of a dull gray color, in places almost black, and with a somewhat metallic lustre. Its specific gravity is 7.1—7.5, and its hardness 5—5.5. It is sometimes feebly magnetic, and contains 67.47 WO . The price quoted for the mineral on the continent is stated to be $375.00 per ton of 65 per cent ore. The demand at present is not large, and is met by an annual output of a few hundred tons. Its principal, if not its only commercial value, is as an alloy for steel. It is believed that, if a large and permanent supply of the mineral could be secured, it would be utilised for hardening armor plate and similar purposes.

Coal.

In 1897 I gave some analyses of the coal from the lower levels of the Springhill seams, and compared them with earlier analyses of the coal from parts of the seams nearer the outcrops. The analyses show that as the coals have been followed down they have increased in their percentage of fixed carbon, and consequently in their steam-raising qualities. This is borne out by the result of analyses made since that date. The average of a number giving the composition of Springhill coal at present is as follows :—

Moisture	2.05
Volatile combustible matter	30.21
Fixed Carbon	63.52
Ash	4.22
	100.00

During the past year a tunnel has been started in the lower workings of the underlying seam to cut some lower beds of coal known to exist some distance to the dip. It has already cut one seam holding about 4½ feet of coal, which gives the following analysis :—

Moisture	3.00
Volatile matter	31.30
Fixed Carbon	62.50
Ash	3.20
	100.00
Sulphur	1.19

The question of the adaptability of the coals of the Dominion Coal Company for iron ore smelting has been a matter of much interest for some time. The principal seam worked by this company is the Phelan. At its outcrop the sulphur average per cent was about 2.5. This would of course be a prejudicial amount in coals destined for blast furnace purposes. It is satisfactory to learn that as the workings in this seam are extended to the dip the percentage of sulphur has materially

decreased. While of course it is possible to materially decrease the percentage of sulphur by crushing and washing the coal, it is the ambition of every mine manager to work a coal seam which can be charged into the coke ovens without preliminary treatment. While this point may not yet be actually reached in the Phalen seam, it is gratifying to notice that the lowering of the percentage of sulphur is rapidly reaching this desirable point. The following average of nearly two hundred analyses of this seam in the lower levels of the various workings will show approximately its present ash and sulphur contents:—

Average.	Per cent.
Ash	3 92
Sulphur	.81

The ash varying from 2.95 to 5.20, and the sulphur from .8 to .93. These results compare more than favorably with the percentages of the corresponding impurities met in the standard American coking coals, and warrant the presumption that in Cape Breton, now that the sulphur question is removed, there are available unlimited quantities of the highest grade of coking coal.

The importance of the possession of a store of such high grade coal is at once seen on reading an editorial in a late number of the *Engineering and Mining Journal*, New York, which states that parts of the great Pittsburg coking seam show signs of partial exhaustion, and that leading operators in the coke trade are turning their attention to the acqisition of coal lands in Virginia as containing the next best available coal for coke making.

VI.—Phenological Observations, Canada, 1898, Compiled by A. H. MacKay, LL.D., *Halifax, from Observations of the Botanical Club of Canada, and of over seven hundred of the Public Schools of Nova Scotia.*

(Read April 17th, 1899.)

In order to continue the publication of the series of the observations of the Botanical Club of Canada, I give hereafter a table of the observations made by the thirteen members making a phenological report for 1898. I can but give a summary of selections from seven hundred reports from as many localities in the Province of Nova Scotia. That these observations are of very great value in measuring the phenological conditions of the various portions of the province can be readily inferred from the facts, that each report comes from a school in which numbers of pupils were observing on their way to and from school under the direction and stimulation of the teacher, and is therefore likely to be in most cases more accurate than one made by a single observer; that the reports represent every part of the province; and that they represent more or less numerous localities in each county of the province.

For the compilation of the tables which immediately follow, ten of the most complete schedules or reports from each county were selected (except in the cases of the counties of Queens, Antigonish and Guysboro, where the full schedules were not sufficiently numerous, and were respectively five, five and six). From these were selected the same TEN plants which had the time of "first flowering" and the time when "flowering was becoming common" both recorded. From these averages or mean dates of flowering have been found, which we may speak of as "phenochrons," the times of the appearances of the phenomena observed expressed in the terms of the days of the year. For such computations it is necessary to have some

simple method of indicating the point of time. For the conversion of the ordinary mensual date to this annual one, or *vice versa*, all that is necessary to assist the operation of mental arithmetic, is to have such a scheme as the following before the eye :—

Day of the year, corresponding to the last day of each month.			
January	31	July	212
February	59	August	243
March	90	September	273
April	120	October	304
May	151	November	334
June	181	December	365

(For *leap* years increase each number except the first by 1.)

Below is a table of phenochrons for the flowering of ten plants in each county, and for each county, for the spring of 1898, in Nova Scotia, based on ten of the best sets of observations made in each county. The first column is the average date of the "first flowering" observed, the second is the average date when the flowering was considered to be "becoming common." The counties are arranged in the order of their phenochrons based on the average of both columns.

	Yarmouth. 130.68.		Annapolis. 132.22.		Kings. 134.19.	
Mayflower	83.0	100.7	89.2	103.8	93.9	104.7
Blue Violet	113.7	126.5	122.5	130.3	122.1	133.1
Red Maple	120.6	129.1	119.0	130.2	117.7	129.2
Dandelion	113.6	126.4	120.2	130.1	124.0	134.4
Strawberry	115.0	130.8	132.3	131.3	116.6	136.5
Wild Red Cherry	137.9	146.9	134.7	142.0	141.3	146.9
Buttercup	131.5	145.3	142.6	150.7	140.3	151.0
Indian Pear	139.5	144.9	136.2	140.0	139.8	143.7
Apple	142.6	152.5	142.2	147.2	144.5	151.5
Lilac	154.7	162.7	151.8	158.1	152.5	160.2
	125.21	136.56	128.07	136.37	129.27	139.12

	Digby. 134.27.		Hants. 134.97.		Shelburne. 135.19.	
Mayflower	92.4	104.4	96.0	109.3	86.1	102.9
Blue Violet	122.8	132.9	122.8	131.2	120.9	128.7
Red Maple	127.9	134.8	119.2	127.0	122.7	131.5
Dandelion	111.9	127.1	124.0	133.2	121.8	129.8
Strawberry	117.5	132.1	123.4	133.5	126.0	135.4
Wild Red Cherry	140.7	150.9	141.1	145.8	144.7	150.5
Buttercup	145.4	155.8	140.3	152.5	139.9	152.1
Indian Pear	138.4	143.7	140.2	144.5	139.2	145.1
Apple	141.6	150.5	146.2	151.5	146.8	153.2
Lilac	151.7	163.0	156.0	161.8	159.0	166.4
	129.03	139.52	130.92	139.03	130.71	139.56
	Pictou. 135.41.		**Lunenburg. 135.43.**		**Queens. 135.72.**	
Mayflower	97.9	111.6	93.4	105.5	90.8	112.0
Blue Violet	121.2	133.4	119.1	132.2	123.4	131.0
Red Maple	122.3	132.3	116.4	127.1	119.4	128.0
Dandelion	120.4	132 3	126.2	134.4	126.2	133.2
Strawberry	124.2	135 5	123.8	133.9	125.4	133.8
Wild Red Cherry	143.3	148.8	140.8	146.2	140.8	145.4
Buttercup	142.0	149.6	149.5	158.0	148.8	157.2
Indian Pear	139.2	144.5	138.2	143.7	139.0	144.6
Apple	146.4	151.7	145.0	151.3	142.6	150.2
Lilac	152.3	159.3	159.2	164.8	157.6	165.0
	131.92	139.90	131.16	139.71	131.40	140.04
	Colchester. 137.23.		**Halifax. 137.29.**		**Cumberland. 139.20.**	
Mayflower	96.8	110.5	92.8	107.2	101.4	111.7
Blue Violet	125.6	136.2	123.7	131.8	132.0	139.0
Red Maple	125.6	133.9	122.7	129.7	130.4	136.1
Dandelion	125.3	134.8	124.7	132.4	131.1	137.8
Strawberry	125.5	136.5	124.9	134.0	130.9	138.8
Wild Red Cherry	141.1	146.6	146.6	151.4	142.7	146.9
Buttercup	148.0	156.8	148.4	156.5	147.1	155.7
Indian Pear	142.5	148.2	139.7	144.7	139.8	146.1
Apple	145.4	151.4	150.4	155.6	147.1	151.3
Lilac	153.7	160.2	161.0	167.7	155.6	162.5
	132.95	141.51	133.49	141.10	135.81	142.59

	Antigonish. 140.93.		Cape Breton. 143.05.		Guysboro. 143.28.	
Mayflower	106.2	120.8	101.5	114.8	100.2	124.2
Blue Violet........	130.2	135.6	131.2	137.9	132.5	141.2
Red Maple	129.6	134.2	133.9	141.6	126.3	138.0
Dandelion	130.0	132.6	130.2	136.5	125.2	139.2
Strawberry........	120.6	136.8	129.2	141.2	130.2	140.5
Wild Red Cherry .	146.8	152 8	151.9	158.7	148.2	151,5
Buttercup	149.0	157.2	153.5	160.2	154.3	164.7
Indian Pear	143.6	147.8	144.9	150.1	146.5	149.8
Apple	154.2	158.8	155.6	160.5	152.0	161.0
Lilac	162.6	169.2	160.9	166.8	167.7	172.7
	134.28	144.58	139.28	146.83	138.30	148.26

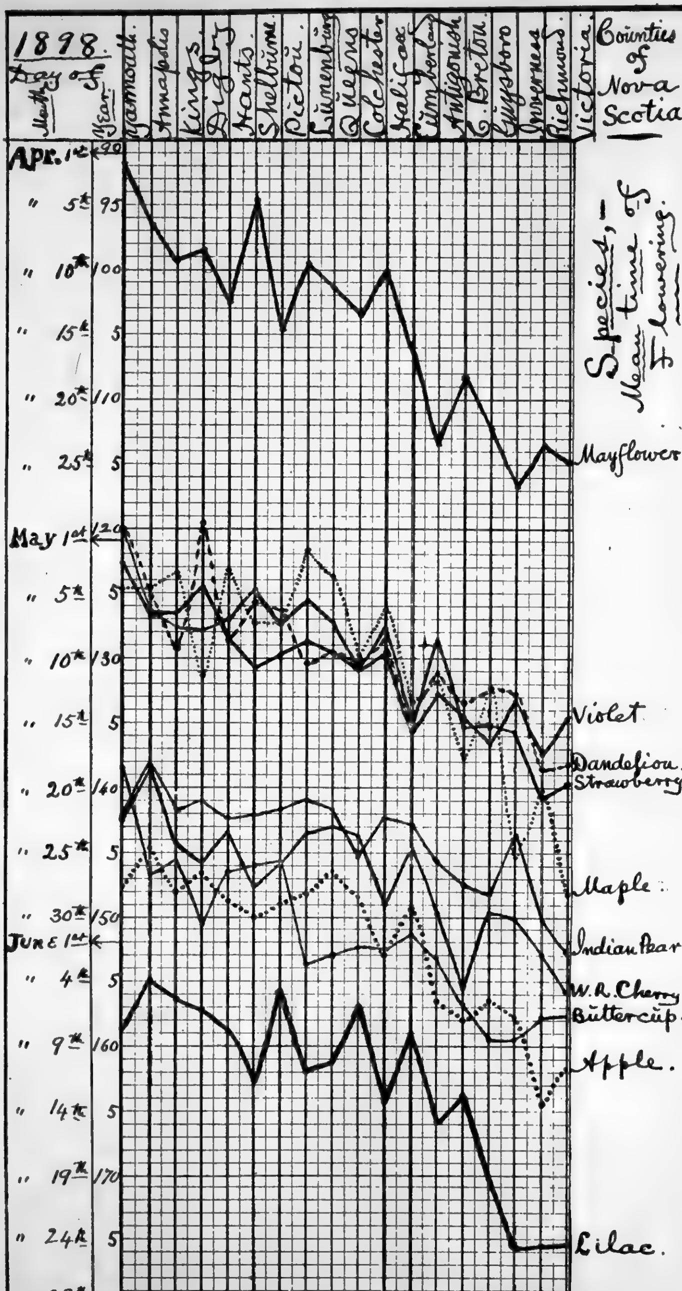
	Inverness. 145.07.		Richmond. 146.65.		Victoria. 147.97.	
Mayflower	111.0	122.4	105.2	121.7	108.2	121.6
Blue Violet........	126.9	139.4	132.9	142.0	131.1	138.3
Red Maple	141.7	149.0	137.0	143.2	146.0	150.4
Dandelion	125.8	139.9	134.7	142.4	134.2	142.5
Strawberry........	129.4	142.0	135.5	145.9	134.4	145.3
Wild Red Cherry	146.0	154,2	149.2	156.9	152.7	159.1
Buttercup	154.9	164.1	152.9	162.9	152.6	162.3
Indian Pear	136.0	151.3	146.0	154.4	148.6	157.3
Apple	153.6	162.2	161.4	167.6	159.5	164.2
Lilac	171.3	180.3	166.4	174.9	172.5	178.7
	139.66	150.48	142.12	161.19	143.98	151.97

Mean Flowering Phenochrons of ten plants in each County of the Province of Nova Scotia for the year 1898, being the Means of Observations at ten stations in each County (excepting Antigonish, Guysboro and Queens, where they are five, six and five respectively). These Phenochrons are the means of the two series of observations, "When first seen" and "When becoming common."

FLOWER.	YARMOUTH.	ANNAPOLIS.	KINGS.
Mayflower	91.85	96.50	99.30
Blue Violet	120.10	126.40	127.60
Red Maple	124.85	124.60	123.45
Dandelion	120.00	125.15	129.20
Strawberry	122.80	126.80	126.55
Wild Red Cherry	142.40	138.35	144.10
Buttercup	138.40	146.65	145.65
Indian Pear	142.20	138.10	141.75
Apple	147.55	144.70	148.00
Lilac	153.70	154.95	156.35
Co. Phenochrons	130.88	132.22	134.19
	DIGBY.	HANTS.	SHELBURNE.
Mayflower	98.40	102.65	94.50
Blue Violet	127.85	127.00	124.80
Red Maple	131.35	123.10	127.10
Dandelion	119.50	126.60	125.30
Strawberry	124.80	128.45	130.70
Wild Red Cherry	145.80	143.45	147.60
Buttercup	150.60	146.40	146.00
Indian Pear	141.05	142.35	142.15
Apple	146.05	148.85	150.00
Lilac	157.35	158.90	162.70
Co. Phenochrons	134.27	134.97	135.13
	PICTOU.	LUNENBURG.	QUEENS.
Mayflower	104.75	99.45	101.4
Blue Violet	127.30	125.65	127.2
Red Maple	127.30	121.75	123.7
Dandelion	126.35	130.30	129.7
Strawberry	129.85	128.85	129.6
Wild Red Cherry	146.05	143.50	143.1
Buttercup	145.80	153.75	153.0
Indian Pear	141.85	140.95	141.8
Apple	149.05	148.15	146.4
Lilac	155.80	162.00	161.3
Co. Phenochrons	135.41	135.43	135.72

FLOWER.	COLCHESTER.	HALIFAX.	CUMBERLAND
Mayflower	103.65	100.00	106.55
Blue Violet	130.90	127.75	135.50
Red Maple	129.85	126.20	133.25
Dandelion	130.05	128.55	134.45
Strawberry	131.00	129.45	134.85
Wild Red Cherry	143.85	149.00	144.80
Buttercup	152 40	152.45	151.40
Indian Pear	145.35	142.20	142.95
Apple	148.40	153.00	149.20
Lilac	156.95	164.35	159.05
Co. Phenochrons	137 23	137.29	139.20
	ANTIGONISH.	CAPE BRETON.	GUYSBORO.
Mayflower	113.50	108.15	112.20
Blue Violet	132.90	134.55	136.85
Red Maple	131.90	137.75	132.15
Dandelion	131.30	133.35	132.25
Strawberry	128.70	135.20	135.35
Wild Red Cherry	149.80	155.30	149.85
Buttercup	153.10	156.85	159.50
Indian Pear	145.70	147.50	148.15
Apple	156.50	158.05	156.50
Lilac	165.90	163.85	170.20
Co. Phenochrons	140.93	143.05	143.28
	INVERNESS.	RICHMOND.	VICTORIA.
Mayflower	116.70	113.45	114.90
Blue Violet	133.15	137.45	134.70
Red Maple	145.35	140.10	148.20
Dandelion	132.85	138.55	138.35
Strawberry	135.70	140.70	139.[illegible]5
Wild Red Cherry	150.10	153.05	155.90
Buttercup	159.50	157.90	157.45
Indian Pear	143.65	150.20	152.95
Apple	157.90	164.50	161.85
Lilac	175.80	170.65	175.60
Co. Phenochrons	145.07	146.65	147.97

On the opposite page these phenochrons are plotted so as to show the characters of the curves.


1898.
Day of Month
Day of Year
Yarmouth.
Annapolis
Kings
Digby
Hants
Shelburne.
Pictou.
Lunenburg
Queens
Colchester
Halifax
Cumberland
Antigonish
C. Breton
Guysboro
Inverness
Richmond.
Victoria.
Counties of Nova Scotia.
Species, — Mean time of Flowering.
Apr. 1st 90
" 5th 95
" 10th 100
" 15th 5
" 20th 110
" 25th 5
May 1st 120
" 5th 5
" 10th 130
" 15th 5
" 20th 140
" 25th 5
" 30th 150
June 1st
" 4th 5
" 9th 160
" 14th 5
" 19th 170
" 24th 5
" 29th 180
Mayflower.
Violet.
Dandelion.
Strawberry
Maple.
Indian Pear.
W. R. Cherry
Buttercup.
Apple.
Lilac.

An interesting irregularity in the phenochrons of the different counties is shown in nearly every part of this table. Their order is not parallel in the different counties. Very often it is reversed. As the phenochrons are averages of ten observations, it cannot be laid altogether to the charge of defective observation. The rarity of certain species in certain counties, or in the districts in which the observations were made, tends to make the phenochron later there, for the plants may be in flower before they are met with. But the character of the soil, the elevation, the slope, &c., must have had some influence. And then, may it not be possible that the same species may develop a tendency to an earlier or later maturing in different regions? These are questions which careful future observations may help to answer.

To illustrate the effect of asymmetry of stations on the phenochrons of a large district of country, I select five of the best observed plants, giving first their phenochrons for a period of seven years, 1892 to 1898, based on the few irregularly distributed stations of the Botanical Club of Canada; secondly their phenochrons for the year 1898, based on the observations made at the eight stations, Berwick, Windsor, Musquodoboit, Wallace, Pictou, New Glasgow and Port Hawkesbury; and giving, thirdly, their phenochrons derived from 180 stations, ten in each of the eighteen counties of the province, observed in connection with the public schools of the province.

First Flowering of the	Seven Year Phenochrons,—Bot. Club.	Phenochrons for 1898,—Bot. Club.	Phenochrons for 1898,—180 Schools.
Mayflower	103.0	93.1	97.0
Maple	125.0	121.8	126.0
Strawberry	129.1	125.7	125.3
Amelanchier	142.6	140.7	140.9
Lilac	155.3	155.1	159.2
General Phenochrons	131.0	127.3	129.7

From the general phenochrons we infer that the Spring of 1898 in the Province of Nova Scotia, was according to the Botanical Club, 3.7 days earlier than the average of the seven years preceding, and according to the Schools only 1.3 days earlier. But what is the cause of this difference of 2.4 days difference between the Club and the Schools? Not defective observations, but the fact that of the eight stations of the Botanical Club, nearly all were either southern or central, while those of the Schools were evenly distributed from Cape Sable to Cape North.

Average flowering dates of five plants selected from the preceding tables, (*a*) for the first nine counties of the Province in the series,—the South-Western; (*b*) for the second nine counties,—the North-Eastern; and (*c*) for the whole Province:

A.—"First Flowering," 1898.

Species.	(*a*) S. W. Counties.	(*b*) N. E. Counties.	(*c*) All Counties.
Mayflower	91.4	102.6	97.0
Strawberry...	121.6	128.9	125.3
Maple...............	120.6	132.6	126.6
Indian Pear	138.8	143.1	140.9
Lilac	155.0	163.5	159.2
Average	125.48	134.14	129.80

B.—"Flowering Becoming Common," 1898.

Species.	(*a*) S. W. Counties.	(*b*) N. E. Counties.	(*c*) All Counties.
Mayflower	106.1	117.1	111.6
Maple.....	129.9	139.6	134.7
Strawberry...........	133.6	140.1	136.8
Indian Pear	143.9	150.0	146.9
Lilac	162.3	170.3	166.3
Average	135.16	143.42	139.26

This table shows at a glance the phenological differences between the warmer and colder halves of the Province, and

also the average difference between the first flowering and when the observers thought it might be said that "flowering was becoming common." In other words, the South-Western half of the Province was in advance of the North-Eastern half as measured by the "first flowering" and when "flowering was becoming common" so far as the said five plants are concerned as follows:

Flowering, 1898.	First Flowering.	Becoming Common.	Average.
Mayflower	11.2 days.	11.1 days.	11.15 days.
Maple	12.0 "	9.7 "	10.85 "
Strawberry	7.3 "	6.5 "	6.90 "
Indian Pear	4.3 "	6.1 "	5.20 "
Lilac	8.5 "	8.0 "	8.25 "
Average	8.66 days.	8.28 days.	8.47 days.

That is, the one half of the Province is on the average eight and a half days in advance of the other half as divided above. The difference between the extreme counties is very much greater, however, as shown by some of the other tables.

MEANS OF TWENTY PHENOLOGICAL OBSERVATIONS, NOVA SCOTIA, FOR THE SEVEN YEARS, 1892 TO 1898, (BOTANICAL CLUB).

Species common to the Tables of the seven years.	Average Date, 1892.	Average Date, 1893.	Average Date, 1894.	Average Date, 1895.	Average Date, 1896.	Average Date, 1897.	Average Date, 1898.	Seven Year Normals or Phenochrons of the Species.	
(First appearance).									
Mayflower, flower.	98	108	104.7	107.0	102.70	106.	93.14	102.79	12 Apr.
Alder, "	102	114	116.3	103.8	107.55	119.	103.50	109.45	19 "
Aspen, "	131	123	122.2	117.5	121.90	128.	118.66	123.18	3 May.
Maple, "	123	130	126.3	123.85	124.55	124.8	121 80	124.90	4 "
Strawberry, "	129	133	131.6	128.55	128.50	126.5	125.75	128.99	8 "
Dog-tooth V., "	135	136	132.2	125.	128.50	131.	126.	130.53	10 "
Cherry (Cult.) "	146	142	146.3	136.6	143.00	146.	141.80	143.10	23 "
Indian Pear, "	145	144	146.	138.35	141.65	141.8	140.71	142.50	22 "
Cherry Wild "	150	144	147.	138.15	145.25	142.6	143.20	144.31	24 "
Apple, "	146	146	152.1	143.7	151.10	155.3	148.40	148.94	28 "
Lilac, "	154	160	162.3	153.5	160.50	157.	155.14	157.49	6 June.
Hawthorn, "	163	160	160.3	148.75	160.25	156.	158.	158.04	7 "
Wild Goose	54	88	70.6	78.00	80.00	80.	73.80	74.91	15 Mar.
Robin	96	94	73.2	99.30	96.14	91.	58.	86.81	27 "
Song Sparrow	99	115	79.	96.65	94.66	95.6	71.	92.99	2 Apr.
Frogs piping	105	113	112.8	110.55	106.30	113.2	101.80	108.95	18 "
Swallow	106	119	119.	125.75	117.76	(117.5)	(117.5)	(117 50)	27 "
Kingfisher	128	137	128.7	127.50	122.00	141.6	130.50	130.76	10 May.
Humming Bird	143	159	143.0	137.25	139.30	143.	143.50	144.01	24 "
Night Hawk	150	134	158.8	148.00	154.33	165.5	145.30	152.28	1 June.
Annual Phenochrons, 1892 to 1898..	125.15	130.45	126.62	124.39	126.30	129.07	120.88	126.12	
Corresponding day of Month	5 May.	10 May	6 May.	4 May.	5 May.	9 May,	30 April.	6 May.	6 May.

To conclude this exhibit of phenological observations, I give a few from those made by the Botanical Club extending across Canada.

CANADA, 1898.

	Nova Scotia.	Muskoka, Ontario.	Pheasant Forks, Assa	Olds, Alberta.	Vancouver, B. C.
Frogs (first Piping)........	101.8	98	112	106	41
Dandelion (first flowering).	124.4	121	150	153	84
Strawberry "	125.7	130	142	142	96
Wild Red Cherry "	143.2	136	161	......	110
Apple	148.4	146	......	......	116
Lilac	155.1	147	182	......	......

To further illustrate what has been done and what has not been done, I give the figures for each of the above six phenomena, so far as obtained, for Nova Scotia, New Brunswick, Ontario (Muskoka and Niagara), Winnipeg, Pheasant Forks in Assiniboia, Olds in Alberta, and Vancouver in British Columbia, for the series of four years from 1895 to 1898.

CANADA, 1895 TO 1898.

FROGS *(First Piping)*.

YEAR.	N. S.	N. B.	Ontario.	Winnipeg.	Ph. Forks.	Olds.	Vancouver.
1895......	110.6	120	106.5	92 5	......	98	53
1896........	106.3	116	104.5	112.	115	......	50
1897	113.2	....	92	104.	105	......	33
1898........	101.8	....	98	....	112	106	41

DANDELION *(First Flowering)*.

YEAR.	N. S.	N. B.	Ontario.	Winnipeg.	Ph. Forks.	Olds.	Vancouver.
1895.......	125.4	131	118.5	123	......	143	99
1896........	128.5	133	121.5	....	149	......	88
1897........	132.4	....	118	135	......	......	89
1898........	124.4	....	121	....	150	153	84

STRAWBERRY *(First Flowering).*

YEAR.	N. S.	N. B.	Ontario.	Winnipeg.	Ph. Forks.	Olds.	Vancouver.
1895........	128 5	126.8	126	129	......	136	110
1896........	128.5	128.5	127.5	144	134	.....	102
1897........	128.6	....	128.5	140	140	.....	89
1898........	125 7	....	130	....	142	142	96
			WILD RED CHERRY *(First Flowering).*				
1895........	139.8	130.5	128	....	......	......	124
1896........	145.2	144	130	....	......	.....	126
1897........	142 6	....	137.5	140	......	.....	111
1898........	143.2	....	146	....	......	......	116
			APPLE *(First Flowering).*				
1895........	143.7	145	129	128	......	......	.....
1896........	151.1	152	131.5	....	......	......	126
1897........	155.3	....	143	....	......	......	117
1898........	148.4	....	146	....	.....	.....	116
			LILAC *(First Flowering).*				
1895........	153.7	150	137.5	136	......	......	125
1896........	160.5	158	133.5	......	......	......	133
1897........	157	....	148	145	......	......	131
1898........	155.1	....	147	....	182	......	......

The blanks in the table above show that the great difficulty is to obtain observers who can keep up their observations regularly for a series of years.

PHENOLOGICAL OBSERVATIONS, CANADA, 1898.

Number	Day of the year 1898, corresponding to the last day of each month. Jan.... 31 July ..212 Feb ... 59 Aug ..243 Mar. .. 90 Sept...273 April..120 Oct... 304 May...151 Nov...334 June..181 Dec....365	Berwick, N. S.	Windsor, N. S.	Halifax, N. S.	Musquodoboit Harbor, N. S.	Wallace, N. S.	Pictou, N. S.	New Glasgow, N. S.	Hawkesbury, N. S.	Charlottetown, P. E. I.	Muskoka, Ont.	Pheasant Forks, Assiniboia.	Olds, Alberta.	Vancouver. B. C.
	Wild Plants Flowering													
1	Alder	95	106	107	....	87	121	....	....	140	110	....	....	[illegible]
2	Aspen	128	....	107	....	....	....	121	....	135	113	133	....	....
3	Mayflower	91	78	....	96	101	86	94	106	105	....	....	....	....
4	Blue Violet	127	113	....	124	135	125	125	144	....	116	140	....	....
5	White Violet	120	....	....	122	127	125	....	144	...	121	....	....	....
6	Red Maple..............	...	108	125	...	...	123	121	132	....	107	....	....	....
7	Bluets (Houstonia).....	....	....	128	....	....	....	....	....	....	....	....	....	....
8	Equisetum..............	....	119	....	...	143	113	124	....	....	130	....	....	....
9	Dandelion	123	106	125	135	131	125	118	132	135	121	150	153	84
10	Adder's-Tongue Lily ...	....	....	....	....	....	126	....	....	....	121	....	....	....
11	Hepatica................	....	....	....	....	....	....	....	....	....	....	....	....	....
12	Gold-Thread	131	....	141	132	140	136	140	144	....	140	....	....	....
13	Strawberry	123	120	129	128	131	128	113	134	142	130	142	142	96
14	do. Fruit ripe..	159	155	164	174	163	168	158	182	....	167	175	173	144
15	Wild Red Cherry	....	140	144	....	138	147	147	....	....	136	161	....	110
16	do. Fruit ripe	....	....	....	....	....	....	....	....	....	192	....	....	....
17	Blueberry	132	121	....	....	142	179	....	....	....	129	....	....	....
18	do. Fruit ripe....	196	....	204	....	202	....	....	....	....	....	....	....	....
19	Ranunculus acris	142	....	156	154	152	....	139	....	...	152	....	....	....
20	Ranunculus repens	....	...	....	....	....	....	....	163	....	....	....	....	....
21	Clintonia...............	139	....	151	152	....	148	....	....	....	....	....	....	....
22	Trilium	139	136	....	150	....	145	....	....	....	134	....	....	....
23	Trientalis	140	149	....	....	....	156	....	....	....	157	....	....	....
24	Cypripedium	149	....	....	156	....	156	....	....	....	....	....	....	....
25	Calla	155	....	...	....	....	....	....	....	....	166	....	....	....
26	Indian Pear	138	132	140	137	...	143	141	154	....	129	142	....	118

PHENOLOGICAL OBSERVATIONS, CANADA, 1898.—*Continued.*

Number.	Day of the year, 1898, corresponding to the last day of each month. Jan.... 31 July ..212 Feb. .. 59 Aug. ..243 Mar ... 90 Sept. ..273 April ..120 Oct ...304 May ..151 Nov ...334 June ..181 Dec ...365	Berwick, N. S.	Windsor, N. S.	Halifax, N. S.	Musquodoboit Harbor, N. S.	Wallace, N. S.	Pictou, N. S.	New Glasgow, N. S.	Hawkesbury, N. S.	Charlottetown, P. E. I.	Muskoka, Ont.	Pheasant Forks, Assiniboia.	Olds, Alberta.	Vancouver, B. C.
	Wild Plants Flowering.													
27	Indian Pear, Fruit......	....	....	....	....	....	....	....	....	....	....	....	....	....
28	Raspberry	149	155	....	172	....	....	....	....	....	....	171	....	....
29	do. Fruit ripe....	....	....	....	203	202	....	....	213	....	197	212	....	....
30	Blackberry	166	....	179	....	....	176	....	182	....	165	....	....	113
31	do. Fruit ripe..	239	....	....	....	....	....	....	230	....	....	....	....	....
32	Pale Laurel............	....	....	....	169	157	....	....	....	....	152	....	....	....
33	Sheep Laurel	144	....	....	177	173	182	....	....	....	....	....	....	....
34	Pigeonberry	138	134	148	168	157	148	....	....	....	158	....	....	....
35	do. Fruit ripe..	....	....	....	....	203	....	....	....	....	....	....	....	....
36	Blue-eyed Grass........	157	....	....	....	149	159	161	177	....	155	171	....	....
37	Linnæa	....	....	....	....	173	175	....	....	....	158	....	....	....
38	Linaria.................	....	....	....	....	....	194	211	....	....	....	....	....	....
39	Rhinanthus	....	....	....	179	....	....	....	....	....	....	....	....	....
40	Sarracenia	....	....	....	174	....	....	....	....	....	....	....	....	....
41	Brunella	180	....	173	179	....	175	....	....	....	169	....	....	....
42	Epilobium	....	....	192	200	195	191	....	....	....	189	....	....	....
43	Rosa lucida	172	....	197	....	....	....	....	182	....	197	....	....	....
44	Hypericum	187	....	195	....	....	201	192	....	....	165	....	....	....
45	Leontodon	211	156	178	....	....	200	....	176	....	198	....	....	....
46	Cherry (cult.) Flower.	138	133	....	144	147	....	144	147	155	....	....	....	102
47	do, Fruit ...	196	....	....	....	203	....	....	....	....	....	....	....	155
48	English Hawthorn	....	....	....	....	....	....	162	....	....	....	....	....	....
49	American Hawthorn ..	....	....	....	....	....	164	152	....	....	157	161	....	133
50	Plum (cultivated)	143	134	....	....	148	145	144	155	....	136	....	....	....
51	Apple (early) Flower...	....	140	153	....	147	....	147	155	152	146	....	....	116
52	do. (late) do. ...	145	....	....	....	....	....	149	....	....	....	....	....	....

PHENOLOGICAL OBSERVATIONS, CANADA, 1898.—*Continued.*

Number.	Day of the year, 1898, corresponding to the last day of each month. Jan.... 31 July ..212 Feb... 59 Aug. ..243 Mar. .. 90 Sept...273 April..120 Oct....304 May...151 Nov...334 June ..181 Dec...365	Berwick, N. S.	Windsor, N. S.	Halifax, N. S.	Musquodoboit Harbor, N. S.	Wallace, N. S.	Pictou, N. S.	New Glasgow, N. S.	Hawkesbury, N. S.	Charlottetown, P. E. I.	Muskoka, Ont.	Pheasant Forks, Assiniboia.	Olds, Alberta.	Vancouver, B. C.
	Wild Plants Flowering.													
53	Currant (red), Flower..	141	134	....	145	140	....	....	147	....	138	146	...	....
54	do Fruit....	197	....	....	197	200	....	....	213	....	189	....	....	....
55	Currant (black), Flower	....	....	....	....	....	....	....	155	....	138	148	....	....
56	do. Fruit....	....	....	...	....	199	....	....	....	....	193	....	....	123
57	Lilac, Flower	153	142	163	160	157	160	151	....	162	147	182	....	....
58	Potato, Flower	180	....	.. ..	....	....	....	....	191	....	179	....	....	....
59	Timothy, Flower	....	....	153	....	....	....	191	202	....	....	....	....	....
60	Clover (white), Flower.	135	148	163	...	156	163	153	176	....	158	....	....	....
61	do. (red), Flower....	153	140	156	....	156	164	153	163	....	158	....	....	....
62	Wheat, Flower	....	....	....	....	....	....	....	....	....	....	....	....	....
63	Oats, Flower	....	....	....	....	....	....	....	....	...	...	....	....	....
64	Buckwheat, Flower....	....	....	....	....	....	....	....	....	....	....	....	....	....
65a	Earliest Leafing	....	....	....	....	....	....	....	....	....	....	....	....	....
65b	Latest Leafing..........	....	....	....	....	....	....	....	....	....	139	....	....	....
	(First Phenomena).													
66	Plowing	....	....	....	....	127	....	....	....	....	100	....	....	....
67	Sowing	....	....	....	....	143	....	....	....	126	106	122	....	....
68	Planting Potatoes......	....	....	....	....	139	....	....	130	....	145	137	....	....
69	Sheep Shearing	143	141	....	....	136	....	....	130	....	131	156	....	..
70	Hay Cutting...........	....	....	130	....	....	....	....	202	....	189	200	....	....
71	Grain Cutting	....	....	223	....	....	....	....	....	231	220	222	....	....
72	Potato Digging	....	....	....	....	269	....	....	....	....	268	283	....	....
73a	Rivers Opening	....	....	....	....	66	....	79	....	94	....	110	....	....
3b	Lakes Opening	....	....	....	....	87	...	82	107	....	....	....	....	....
74a	Ground Snow, Spring.	....	117	....	116	116	....	117	96	....	109	....	118	....
74b	Air " "	....	....	....	....	....	....	....	116	....	109	....	119	....

PHENOLOGICAL OBSERVATIONS, CANADA, 1898—*Continued.*

Number.	Day of the year, 1898, corresponding to the last day of each month. Jan.... 31 July...212 Feb.... 59 Aug ..243 Mar. .. 90 Sept. ..273 April ..120 Oct....304 May ..151 Nov...334 June ..131 Dec. ..365	Berwick, N. S.	Windsor, N. S.	Halifax, N. S.	Musquodoboit Harbor, N. S.	Wallace, N. S.	Pictou, N. S.	New Glasgow, N. S.	Hawkesbury, N. S.	Charlottetown, P. E. I.	Muskoka, Ont.	Pheasant Forks, Assiniboia.	Olds, Alberta.	Vancouver, B. C.
	(First Phenomena,)													
75a	Hard Frost, Spring	....	....	....	....	....	....	....	....	130	77	165	....	119
75b	Hoar Frost, Spring	168	....	....	....	....	....	161	....	....	108	....	187	....
76a	Streams "highest"	....	....	....	....	....	....	....	....	....	....	....	....	....
76b	do. "lowest"	....	....	....	....	....	....	....	....	....	....	....	....	....
77a	Hoar Frost, Autumn	255	....	255	....	268	....	....	240	....	316	....	241	....
77b	Hard Frost, "	....	....	331	....	283	....	283	305	285	254	251	....	....
78a	Air Snow, "	....	....	....	316	....	....	....	264	....	287	....	246	....
78b	Ground Snow, "	....	....	....	319	....	....	319	283	315	290	....	273	....
79a	Lakes Closing	....	....	....	....	....	....	....	....	....	....	....	....	....
79b	Rivers Closing	....	....	....	....	....	....	343	....	363	....	319	....	....
80	Thunder	....	....	....	23	....	....	....	....	....	....	....	....	....
		....	....	....	....	....	....	....	43	....	....	....	....	....
		106	105	....	....	....	....	....	77	....	75	....	116	....
		....	140	....	106	....	....	....	159	....	131	122	130	....
		....	....	182	182	182	....	182	163	182	149	151	142	....
		....	....	....	....	183	....	184	176	....	152	153	158	....
		....	....	....	....	184	....	185	182	....	158	163	160	....
		....	....	....	....	....	....	....	....	185	175	171	170	....
		....	....	....	....	....	....	....	....	....	181	177	171	....
		....	....	....	....	....	....	....	....	....	189	182	172	....
		....	....	....	....	....	....	....	....	....	199	183	175	....
		....	....	....	....	....	....	....	....	....	....	191	178	....
		....	....	....	....	....	....	....	....	....	....	198	179	....
		....	....	....	....	....	....	....	....	....	....	....	180	....
		....	....	....	....	....	....	....	....	....	....	....	182	....
		....	....	....	....	....	....	....	....	....	....	....	183	....
		....	....	....	....	....	....	....	....	....	....	....	185	....

PHENOLOGICAL OBSERVATIONS, CANADA, 1898,—*Continued.*

Number.	Day of the year, 1898, corresponding to the last day of each month. Jan.... 31, Feb .. 59, Mar. .. 90, April ..120, May ...151, June ..181, July ...212, Aug .. 243, Sept .. 273, Oct ....304, Nov ...334, Dec 365	Berwick, N. S.	Windsor, N. S.	Halifax, N. S.	Musquodoboit Harbor, N. S.	Wallace, N. S.	Pictou, N. S.	New Glasgow, N. S.	Hawkesbury, N. S.	Charlottetown, P. E. I.	Muskoka, Ont.	Pheasant Forks, Assiniboia.	Olds, Alberta.	Vancouver, B. C.
	(First Phenomena.)													
		....	....	....	....	....	....	....	....	....	....	....	186	....
		....	....	....	....	....	....	....	....	....	....	....	192	....
		....	....	....	....	....	....	....	....	....	....	....	193	....
		....	....	....	....	....	....	....	....	....	....	....	197	....
		....	....	....	....	....	....	....	....	....	....	....	199	....
		227	....	235	235	221	....	218	201	212	200	204	202	....
		....	....	....	....	229	....	....	214	221	209	205	203	....
		....	....	....	....	....	....	....	....	....	....	....	206	....
		....	....	....	....	....	....	....	....	....	....	....	209	....
		...	....	....	....	....	....	....	....	....	....	212	210	....
		....	....	....	....	....	....	....	221	....	215	215	215	....
	Thunder *(Continued)*	....	....	....	....	....	....	....	....	....	....	220	221	....
		....	....	....	....	....	....	....	....	....	....	....	223	....
		....	....	....	....	....	....	....	....	....	224	225	224	....
		....	....	....	....	....	....	....	....	....	227	226	226	....
		....	....	....	....	....	....	....	....	....	....	231	232	....
		....	....	....	....	234	....	....	233	...	234	232	233	....
		237	....	237	237	....	....	237	237	236	239	...	238	....
		248	....	....	....	247	....	238	....	....	....	245	246	....
		....	....	....	....	248	....	247	....	248	250	....	262	....
		....	....	....	....	....	....	....	....	259	258	266	263	....
		....	....	....	270	265	....	....	....	....	276	288	265	....
		....	....	....	303	332	....	....	303	....	....	....	314	....
	(First Migration.)													
81	Wild Duck.............	....	....	....	....	....	....	....	....	....	....	103	96	....
82	Wild Goose, going north	75	....	62	....	72	74	86	....	73	....	95	96	....
	do. going south	....	..	....	....	....	....	....	....	....	300	....	276	....

PHENOLOGICAL OBSERVATIONS, CANADA, 1898,

Number.	Day of the year, 1898, corresponding to the last of each month: Jan.... 31, Feb,... 59, Mar... 90, Apl ...120, May...151, June ..181, July...212, Aug...243, Sept...273, Oct....304, Nov...334, Dec....365	Berwick, N. S.	Windsor, N. S.	Halifax, N. S.	Musquodoboit Harbor, N. S.	Wallace, N. S.	Pictou, N. S.	New Glasgow, N. S.	Hawkesbury, N. S.	Charlottetown, P. E. I.	Muskoka, Ont.	Pleasant Forks, Assiniboia.	Olds, Alberta.	Vancouver, B. C.
	(First Migration.)													
83	Song Sparrow	74	....	73	....	....	....	....	66	78	78	...	84	....
84	American Robin	67	....	65	....	74	....	....	26	93	...	108	100	....
85	Junco	74	...	84	....	85	....	....	....	90	....	5	....	....
86	Spotted Sandpiper	....	....	143	....	....	....	....	132	....	....	....	....	....
87	Meadow Lark	....	....	....	....	....	....	....	....	....	....	....	....	....
88	Kingfisher	....	....	129	....	....	....	....	132	....	....	....	....	....
89	Yellow Crown Warbler	....	....	....	....	....	....	....	111	....	....	....	....	....
90	Summer Yellow Bird	130	....	....	....	....	....	135	130	....	....	....	....	....
91	White Throat Sparrow.	....	....	126	....	....	....	....	....	142	....	....	....	....
92	Humming Bird	141	134	....	142	144	....	155	145	....	136	143	....	....
93	King Bird	....	....	142	....	....	....	....	147	....	....	....	....	....
94	Bobolink	124	134	....	....	....	....	....	155	....	....	....	....	....
95	American Goldfinch	136	....	....	....	....	....	....	144	....	....	....	....	....
96	American Redstart	....	....	151	....	....	....	....	....	....	....	....	....	....
97	Cedar Waxwing	....	....	....	....	....	....	....	....	....	....	....	....	....
98	Night Hawk	145	....	144	....	....	....	....	202	147	146	145	....	....
99	Frogs heard	89	...	104	....	106	100	....	110	107	98	112	106	41
100	Snakes seen	129	....	....	....	....	....	....	132	....	100	118	....	....

VII.—Observations on a Fish (*Chylomycterus schœpfi*) new to the Fauna of Nova Scotia. By Harry Piers.

(Read May 8th, 1899.)

In the summer of about 1896 a curious fish was brought to the Provincial Museum by a fisherman who had taken it in deep water off Sambro near Halifax.

At Dr. Gilpin's request I examined the specimen and found that it belonged to the species *Chylomycterus schœpfi*, (Walbaum) which is the same as *Chilomycterus geometricus*, Kaup, and *Diodon maculostriatus*, Mitchell. It is variously known as the Common Burr-fish, Rabbit-fish, Swell-toad, or Swell-fish. The specific name *schœpfi* was given it in honour of its discoverer, Dr. Johann David Schöpf, a Hessian surgeon in the American revolutionary war and a noted botanical collector.

It is a small, elliptical-oval shaped species of remarkable appearance. The bones of the upper and lower jaws are confluent, forming a short beak with a trenchant edge, without teeth. Unlike those of the Tetrodons, these plates are without a median suture. The body is covered with short, stout, triangular, dermal spines, each with three roots and consequently immovable. It is thus well protected from enemies, and would prove a thorny morsel to any marine animal foolish enough to capture it.

When fresh from the water the upper parts are greenish-black with a series of undulating blackish stripes running from the head backward; a similar series between eyes and across face; an ocellated black spot above pectoral; a larger one behind the same fin; another ocellated spot at the base of the dorsal, with a smaller spot below it. The specimen has now lost much of its colour in alcohol, but the markings may still be traced.

Length 3 inches*, of which the tail forms about $\frac{1}{2}$ inch. Fin rays: dorsal, 12; pectoral, 21; anal, about 10; caudal, 9.

This species has not previously been taken in Nova Scotian waters, in fact it has never hitherto been captured so far north. According to Jordan and Evermann (Fishes of North and Middle America, 1898), its range is from Cape Cod to Florida. It is very abundant southward in shallow water, being particularly plentiful on the coast of the Carolinas and Florida.

C. schœpfi belongs to the *Diodontidæ* family (Porcupine Fishes), all the members of which are sluggish, living on the bottom among weeds and corals, in tropical seas. When disturbed, they swallow air until considerably inflated, and then float belly upward on the water. In such a condition they could be easily driven before the wind. They are popularly regarded as poisonous.

* The usual length is from 6 to 10 inches.

Date of publication; December 31st, 1899.

TRANSACTIONS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1899-1900.

I.—On the Relation of the Viscosity of Mixtures of Solutions of Certain Salts to their State of Ionization. — By James Barnes, B. A., *Dalhousie College, Halifax, N. S.*

(Communicated by Prof. J. G. MacGregor on December 15th, 1899)

The present paper is the result of a piece of work undertaken at the suggestion of Prof. MacGregor, for the summer vacation of 1899, the object being to find out in the case of mixtures of aqueous solutions of certain electrolytes with a common ion, whether or not it is possible, by the aid of the dissociation conception, to predict the viscosities of the mixtures, when sufficient data as to the viscosities and conductivities of the constituent solutions are available.

The salts selected were sodium chloride, potassium chloride, barium chloride, sodium sulphate, potassium sulphate, and copper sulphate, the viscosities of simple solutions of these salts having been determined by [1] Reyher and [2] Wagner, and that of mixtures of them by [3] Kanitz, and extensive series of observations on the conductivity by Kohlrausch and by former students of Dalhousie College, being available. As will be seen below I found [4] Kohlrausch's values of the conductivity sufficient for my purpose.

[1] Ztschr. f. phys. Chemie, 2, 744, 1888.
[2] *Ibid.*, 5, 31, 1890.
[3] *Ibid.*, 22, 336, 1897.
[4] Kohlrausch u. Holborn : Leitvermögen der Elektrolyte, 1898, pp. 159, 160, tab. 2.

[1] Professor MacGregor has pointed out that, both on theoretical grounds and because of the way in which the ionization coefficients and such physical properties as specific gravity, viscosity, etc., in general, vary with the concentration in simple solutions, it is to be expected that the value of any such property, for a simple solution which is so dilute that the dissociated and undissociated molecules may be regarded as without mutual action, will be expressed by the formula:

$$P = P_w + k(1-a)\,n + l\,a\,n, \quad\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where P is the numerical value of the property for the solution, P_w that of the same property for water under the same physical conditions, n the concentration expressed in gramme-equivalents per unit volume, a the ionization coefficient of the electrolyte in the solution, and k and l constants, called ionization constants.

He has further shown that the value of a property for a mixture of two electrolytes will be given in terms of the values of the ionization constants as determined for the simple solutions, by the expression:

$$P = P_w + \frac{1}{p}\left[\left(k_1(1-a_1)\,n_1 + l_1\,a_1\,n_1\right)\frac{v_1}{v_1+v_2} + \left(k_2(1-a_2)\,n_2 + l_2\,a_2 n_2\right)\frac{v_2}{v_1+v_2}\right] \ldots (2)$$

where the n's are the concentrations of the constituent solutions (the electrolytes being indicated by 1 and 2), the a's the ionization coefficients of the respective electrolytes in the mixture, the v's the volumes of the constituent solutions, and p the ratio of the volume of the mixture to the sum of the volumes of the constituent solutions.

The application of the first expression to simple solutions is, as [2] Prof. MacGregor has shown, of little theoretical interest; but that of the second to mixtures, because of its being based on the dissociation theory and involving no arbitrary constants, is of very considerable interest. It is the applicability of this expression (2) that the present paper is intended to test with mixtures of solutions of the above-mentioned salts.

---

[1] Trans. N. S. Inst. Sci., 9, 219, 1896-97.

[2] Trans. N. S. Inst. Sci., 10, 61 (foot note), 1898-99.

The observations of Reyher, Wagner and Kanitz were made on somewhat stronger solutions than those for which the above expressions might be expected to hold, but they were considered as probably sufficiently dilute to warrant the expectation of an approximate applicability of the expressions.

Simple Solutions.

For the determination of the ionization constants in expressions (1) and (2), one must know the ionization coefficients for the four solutions examined in the case of each salt by Reyher and Wagner. Unfortunately all the observations on the viscosity of these salts were made at 25° C., while all the available conductivity data, from which the ionization coefficients are obtained, were at 18°C., and thus it was necessary either to reduce the viscosity values from 25° to 18° or the conductivity values from 18° to 25°. This latter reduction was carried out, as data for the former were not available. This involved much work; because for the determination of the ionization coefficients at 25°, it was necessary to obtain both the specific molecular conductivity at 25° and the specific molecular conductivity at infinite dilution for 25°.

Determination of the Specific Molecular Conductivity at Infinite Dilution for 25°C.

The value of the specific molecular conductivity at infinite dilution for 25° for each salt was obtained from [1] Kohlrausch's value at 18° by aid of [2] Déguisne's data. These data were employed in obtaining the specific molecular conductivity at 25° from the values at 18°, for the three weakest solutions given in [3] Kohlrausch's and Déguisne's tables; and the ratio $\frac{\mu_{25}-\mu_{18}}{\mu_{18}}$ was then determined, where μ_{25} and μ_{18} are the specific molecular conductivity at 25° and 18° respectively.

Table I gives the values thus obtained. The concentrations are expressed in gramme-equivalents per litre, and the specific molecular conductivities in terms of this unit and of 10^{-4} times [4] Kohlrausch's new unit of conductivity ($\text{ohm}^{-1}\ \text{cm.}^{-1}$).

[1] Kohl. u. Holb., *loc. cit.*, p. 200, tab. 8.
[2] *Ibid.*, p. 195, tab. 7.
[3] *Ibid.*, pp. 159, 160, tab. 2.
[4] *Ibid.*, p. 1.

TABLE I.

Concentration.	Sp. Mol. Cond. at 18° C. (μ_{18})	Sp. Mol. Cond. at 25° C. (μ_{25})	$\frac{\mu_{25} - \mu_{18}}{\mu_{18}}$
	Na. Cl.		
.0005	1085	1262	.163
.0002	1092	1270	.163
.0001	1097	1276	.163
	K Cl		
.0005	1283	1484	.156
.0002	1291	1494	.157
.0001	1295	1499	.157
	½ Ba Cl_2.		
.0005	1183	1375	.162
.0002	1198	1394	.163
.0001	1205	1402	.163
	½ K_2 SO_4.		
.0005	1308	1516	.159
.0002	1327	1540	.160
.0001	1335	1549	.160
	½ Na_2 SO_4.		
.0005	1083	1266	.169
.0002	1096	1281	.169
.0001	1105	1292	.169

As the ratio $\frac{\mu_{25}-\mu_{18}}{\mu_{18}}$ was thus found to be constant for the two most dilute solutions of every salt, and as these solutions are very dilute, this ratio may be assumed to approximately hold for infinite dilution. Observations on the conductivity of weaker solutions at different temperatures were not at hand; and the writer used the value of this ratio for the solution of concentration .0001 for the calculation of the specific molecular conductivity at infinite dilution for 25° C.

The following Table II gives the values of the specific molecular conductivity at infinite dilution for 25° C. as thus obtained from the values at 18° C. In the case of copper sulphate this method could not be employed for want of data. A somewhat doubtful value obtained by [1]Bredig was therefore used. The conductivities are expressed as in Table I.

TABLE II.

Electrolyte.	Specific Molecular Conductivity at Infinite Dilution.	
	18° C.	25° C.
Na Cl.	1103	1283
K Cl.	1312	1519
$\frac{1}{2}$ Ba Cl_2.	1232	1433
$\frac{1}{2}$ K_2 SO_4.	1350	1566
$\frac{1}{2}$ Na_2 SO_4.	1141	1334
$\frac{1}{2}$ Cu SO_4.....	....	1423

Determination of the Ionization Coefficients at 25° C. for Simple Solutions.

The ionization coefficient for a simple solution is taken to be the ratio of the specific molecular conductivity to the specific

[1] Ztschr. f. phys. Chem., 13, 220, 1894,

molecular conductivity at infinite dilution. Before this ratio could be found for 25° C. it was necessary to determine the values of the specific conductivity at 25° from [1] Kohlrausch's values at 18° by means of [2]Déguisne's and [3]Kohlrausch and Grotrian's temperature coefficients. The concentrations of solutions of the salts for which Kohlrausch gives conductivity values, did not in all cases correspond to the concentrations of solutions for which Reyher and Wagner determined the viscosity. In such cases (concentrations 0.25 and 0.125), the values of the specific conductivities at 25° were obtained by interpolation.

Table III gives both the values of the specific conductivity at 25°C. determined as above from the values at 18°, and the calculated ionization coefficients at 25°. Only those coefficients are given which are necessary in the calculation of the viscosities. Under copper sulphate are given a few conductivity values of higher concentration, these being necessary for the determination of the ionization coefficients in the mixtures by the method used. The concentrations are expressed as in Table I, and conductivities in terms of 10^{-4} times Kohlrausch's new unit.

---

[1] Kohl. u. Holb., *loc. cit.*, p. 159, table 2.

[2] *Loc. cit.*

[3] Kohl. u. Holb., p. 145, tab. 1.

TABLE III.

Concentration.	Specific Conductivity at 18° C.	Specific Conductivity at 25° C.	Ionization Coefficients at 25° C.
		Na Cl.	
1.0	744.0	862	.672
0.5	404.5	469	.732
0.3	255.6	296	......
0.25	......	252	.786
0.2	176.4	205	......
0.125	......	131	.817
0.1	92.5	107	......
		K Cl.	
1.0	982.0	1128	.743
0.5	511.5	588	.774
0 3	315.9	363	......
0.25	......	308	.811
0.2	215.4	248	......
0.125	......	159	.838
0.1	111.9	129	......
		½ Ba Cl_2.	
1.0	703	811	.566
0.5	388	448	.624
0.3	249	287	......
0.25	......	245	.684
0.2	173.4	200	......
0.125	......	130	.726
0.1	92.2	106	......

TABLE III.—(*Continued.*)

Concentration.	Specific Conductivity at 18° C.	Specific Conductivity at 25° C.	Ionization Coefficients at 25° C.
$\frac{1}{2}K_2SO_4$			
1.0	718.0	827	.528
0 5	393.5	453	.578
0.3	253.2	292	......
0.25	......	251	.640
0.2	177.8	205	......
0.125	......	135	.690
0.1	95.9	111	......
$\frac{1}{2}Na_2SO_4$.			
1.0	508 0	591	.443
0.5	298.5	347	.520
0.3	199.8	230	.....
0.25	..... .	201	.604
0.2	142.8	166	......
0.125	......	110	.662
0.1	78.4	91.4	......
$\frac{1}{2}CuSO_4$.			
2.631	458	534	......
2.194	421	489	......
1.0	258	297	.209
0.5	154	177	.249
0.3	106.5	122	......
0.25	......	107	.302
0.2	78.4	89.9	......
0.125	......	61.7	.347
0.1	45.0	51.6	......

Determination of the Ionization Constants.

Table IV gives the values of the ionization constants (k and l) determined by the method of least squares from the data given in Tables III and V, the observed values of the viscosity of the four solutions of each salt being used. The relative magnitude and the sign of the ionization constants would seem to show that the undissociated molecules exert the greater influence in increasing the viscosity, while the free ions have in some cases a diminishing effect.

TABLE IV.

Electrolyte.	k.	l.
Na Cl.	+0.11213	+0.089765
K Cl.	+0.30645	−0.12289
½ $BaCl_2$.	+0.20327	+0.061009
½ K_2SO_4.	+0.21347	+0.0088236
½ Na_2SO_4.	+0.30418	+0.13348
½ $CuSO_4$.	+0.46500	−0.058144

Results of Calculations on Simple Solutions.

Table V gives a comparison of the calculated and observed values of the viscosity of simple solutions, the calculated values being determined by expression (1) with the ionization coefficients and ionization constants, as given in the above tables. In this table all the viscosity results are relative to water at 25°C., and the concentrations are expressed as in Table I.

TABLE V.

VISCOSITY AT 25° C.

Concentration.	Observed Value.	Calculated Value.	Difference.
	Na Cl. (Reyher.)		
1.0	1.0973	1.0971	$-0.0_{3}2$
0.5	1.0471	1.0479	$+0.0_{3}8$
0.25	1.0239	1.0236	$-0.0_{3}3$
0.125	1.0126	1.0117	$-0.0_{3}9$

TABLE V.—*(Continued).*

Concentration.	Observed Value.	Calculated Value.	Difference.
	K Cl. (Wagner.)		
1.0	.9872	.9874	$+ 0.0_32$
0.5	.9874	.9871	$- 0.0_33$
0.25	.9903	.9896	$- 0.0_37$
0.125	.9928	.9933	$+ 0.0_35$
	½ $Ba\ Cl_2$. (Wagner.)		
1.0	1.1228	1.1228	$\pm 0.0_30$
0.5	1.0572	1.0572	$\pm 0.0_30$
0.25	1.0263	1.0265	$+ 0.0_32$
0.125	1.0128	1.0125	$- 0.0_33$
	½ K_2SO_4. (Wagner.)		
1.0	1.1051	1.1054	$+ 0.0_33$
0.5	1.0486	1.0476	$- 0.0_21$
0.25	1.0206	1.0206	$\pm 0.0_30$
0.125	1.0078	1.0090	$+ 0\ 0_212$
	½ Na_2SO_4. (Wagner.)		
1.0	1.2291	1.2286	$- 0\ 0_35$
0.5	1.1058	1.1078	$+ 0.0_22$
0.25	1.0522	1.0502	$- 0.0_22$
0.125	1.0235	1.0239	$+ 0.0_34$
	½ $Cu\ SO_4$. (Wagner.)		
1.0	1.3580	1.3556	$- 0.0_224$
0.5	1.1603	1.1675	$+ 0.0_272$
0.25	1.0802	1.0767	$- 0.0_235$
0.125	1.0384	1.0354	$- 0.0_230$

As both Reyher and Wagner regard their results as affected by a possible error of about ± 3 in the third decimal place, it is seen that the agreement between the calculated and observed values for all the salts except copper sulphate is very satisfactory, the differences being well within the limit of experimental error. In the case of copper sulphate, the agreement is not so satisfactory. But it was noticed on plotting the observed values against the concentration that the points do not lie on a smooth curve, and that the point corresponding to the concentration 0.5 is at quite a distance from this curve, which leads one to think that this observed value cannot be correct. The poor agreement in this case might also be partly due to the doubtful value of the specific molecular conductivity at infinite dilution used. Thus it seems that for all the salts examined, copper sulphate perhaps excepted, expression (1) gives the viscosity of a solution within the limit of experimental error throughout a concentration range of 1.0 to 0.125.

Mixtures of Solutions.

As there is no change of volume on mixing the constituent solutions of the above electrolytes of the concentrations given below[1], and as the solutions mixed were of equal volume and also equimolecular, the expression (2) for the value of a property in the case of a mixture of two electrolytes with a common ion, reduces to:

$$P = P_w + \frac{n}{2}\left[k_1 (1 - a_1) + l_1 \; a_1 + k_2 (1 - a_2) + l_2 \, a_2\right] . \quad (3)$$

where n is the concentration of the solutions and the k's and l's have the values obtained above for simple solutions of the respective electrolytes. For the application of this equation to the calculation of the viscosity of a mixture, all the quantities required are known except the a's, the ionization coefficients in the mixture.

---

[1] See Trans. N. S. Inst. Sci., 9, 125, 1895-96; also 9, 297 and 310, 1897-98.

Determination of Ionization Coefficients in the Mixture.

The method proposed by [1] Prof. MacGregor for finding the ionization coefficients in a mixture of two electrolytes having an ion in common, is by solving graphically the following equations:

$$\frac{a_1}{V_1} = \frac{a_2}{V_2}, \qquad (4)$$

$$N_1 V_1 + N_2 V_2 = 1, \qquad (5)$$

$$\frac{a_1}{V_1} = f_1(V_1), \qquad (6)$$

$$\frac{a_2}{V_2} = f_2(V_2), \qquad (7)$$

where the electrolytes are denoted by 1 and 2, the concentrations (in gramme-equivalents per litre) of the mixture with respect to them by N_1 and N_2 respectively, their ionization coefficients by a_1 and a_2, and their regional dilutions (in litres per gramme equivalent) by V_1 and V_2, the regional dilutions being the dilutions of the electrolytes in the regions which they are supposed to occupy in the mixture, or the dilutions of the constituent isohydric solutions.

His graphical mode of solving these equations involves the drawing of dilution-ionic-concentration curves, which, as they have great curvature for moderately dilute solutions, cannot be drawn with great accuracy unless a large number of observations of the conductivity are available. As mentioned above, extensive series of observations of the conductivity in the case of the salts under consideration were available; but they were all made at 18° C. and required therefore to be reduced to 25° C. before they could be used. In order to reduce this labour as much as possible I devised another mode of solution which requires only a comparatively small number of observations. It is based on the fact that the specific-conductivity-concentration

[1] Trans. N. S. Inst. Sci., 9, 101, 1895-96; also 10, 68, 1898-99.

curve of an electrolyte exhibits only slight curvature and can therefore be drawn with fair accuracy from a small number of observations.

The above equations may be expressed in terms of specific conductivity and concentration as follows. Since

$$\frac{a_1}{V_1} = \frac{\mu_1}{V_1\mu_{\infty 1}} = \frac{k_1}{\mu_{\infty 1}}, \quad . \quad . \quad (8)$$

and

$$\frac{a_2}{V_2} = \frac{k_2}{\mu_{\infty 2}}, \quad . \quad . \quad . \quad . \quad (9)$$

where k_1 and k_2 are the specific conductivities of the electrolytes in the regions which they respectively occupy in the mixture, and the μ_∞'s the specific molecular conductivities at infinite dilution for each electrolyte, equation (4) becomes:

$$\frac{k_1}{\mu_{\infty 1}} = \frac{k_2}{\mu_{\infty 2}},$$

or,

$$k_1 = \frac{\mu_{\infty 1}}{\mu_{\infty 2}} k_2. \quad . \quad . \quad . \quad (10)$$

From equation (5) we obtain:

$$\frac{N_1}{C_1} + \frac{N_2}{C_2} = 1, \quad . \quad . \quad . \quad (11)$$

where C_1 and C_2 are the regional concentrations. Equations (6) and (7) are based on the fact that at a definite temperature the conductivity is a function of the concentration alone. They therefore take the following forms:

$$k_1 = f_1\,(C_1), \quad . \quad . \quad . \quad . \quad (12)$$

and

$$k_2 = f_2\,(C_2). \quad . \quad . \quad . \quad . \quad (13)$$

There are thus four equations (10—13) for the determination of the four unknown quantities: k_1, k_2, C_1, and C_2.

These equations can be solved graphically. Equation (12) is employed by drawing a curve having as abscissæ the values of the specific conductivities and corresponding values of the concentrations as ordinates. Before equation (13) is used the values

of the conductivities are multiplied by the constant $\frac{\mu_{\infty 1}}{\mu_{\infty 2}}$. Then these new values are plotted against the corresponding concentrations, on the same coordinate paper, to the same scale as employed for equation (12). From these two curves one finds by inspection two points, one on each curve, having a common abscissa, according to equation (10), and ordinates (C_1 and C_2) such that by substituting their values in equation (11) it will be satisfied. These points can be found after two or three trials. Thus one has determined k_1, C_1, and C_2; k_2 being found by multiplying k_1 by the constant $\frac{\mu_{\infty 2}}{\mu_{\infty 1}}$. The a's are now obtained from equations (8) and (9); for the reciprocals of the C's give the V's.

Results of the Calculations on Mixtures.

The following Table VI contains the requisite data for the calculation, by formula (3), of the viscosity of mixtures of solutions of the salts under consideration; and it shows the agreement of the values thus calculated with the observed values The ionization coefficients of the salts in the mixture are determined as above and the concentrations are expressed as in the former tables.

TABLE VI.

VISCOSITY AT 25°. (KANITZ).

Concentration Constituent Solutions.		Ionization Coefficients in Mixture.		Observed Values.	Calculated Values.	Difference.
K Cl.	Na Cl.	K Cl.	Na Cl.			
1.0	1.0	.745	.667	1.0390	1.0419	$+0.0_{2}29$
0.5	0.5	.775	.728	1.0180	1.0173	$-0.0_{3}7$
0.25	0.25	.807	.783	1.0070	1.0069	$-0.0_{3}1$
K Cl.	½ Ba Cl_2.	K Cl.	½ Ba Cl_2.			
1.0	1.0	.756	.552	1.0429	1.0533	+0.0101
0.5	0.5	.779	.613	1.0159	1.0220	$+0.0_{2}61$
0.25	0.25	.811	.675	1.0049	1.0082	$+0.0_{2}33$
½ K_2SO_4.	½ Na_2SO_4.	½ K_2SO_4.	½ Na_2SO_4.			
1.0	1.0	.535	.434	1.1660	1.1670	$+0.0_{2}1$
0.5	0.5	.597	.517	1.0773	1.0768	$-0.0_{3}5$
0.25	0.25	.641	.604	1.0334	1.0354	$+0.0_{2}2$
½ K_2SO_4.	½ Cu SO_4.	½ K_2SO_4.	½ Cu SO_4.			
1.0	1.0	.559	.152	1.2240	1.2423	+0.0183
0.5	0.5	.612	.210	1.1060	1.1107	$+0.0_{2}47$
0.25	0.25	.668	.256	1.0485	1.0510	$+0.0_{2}25$

Kanitz regards his observed values as affected by a possible error of ± 3 in the third decimal place. Considering the many calculations necessary to obtain the calculated values,—first, in finding the specific molecular conductivity at infinite dilution for 25°C., and also ionization coefficients at 25° from data at 18°, and then in the determination of the ionization coefficients of the salts in the mixture by the graphical method,—the agreement between the observed and the calculated values (calculated,

it should be noted, with the ionization constants obtained for the simple solutions), is very satisfactory, especially in the case of solutions of potassium chloride and sodium chloride and solutions of potassium sulphate and sodium sulphate, where the differences are all within the limit of experimental error. In the case of the stronger solutions of potassium chloride and barium chloride and of potassium sulphate and copper sulphate, the differences are not within the limit of error; but a close agreement, as was pointed out in the beginning, could not be expected. It will be noticed, however, that the differences in these cases diminish and approach the experimental error as concentration diminishes. Observations on the viscosity of weaker solutions of these salts were not available.

From these results, therefore, it may be concluded, that the viscosity of mixtures of dilute solutions of the salts under consideration can be predicted, by the aid of the dissociation theory, within the limit of experimental error, from data as to the viscosity and conductivity of the constituent solutions only.

II.—On the Calculation of the Conductivity of Aqueous Solutions containing Hydrochloric and Sulphuric Acids.—By James Barnes, B. A., *Dalhousie College, Halifax, N. S.*

(Communicated by Prof. J. G. MacGregor, on the 15th January, 1900.)

The prediction of the conductivity of dilute aqueous solutions containing two electrolytes, which have one ion in common, has been shown to be possible, according to the dissociation theory, when the electrolytes are salts, or a salt and a diatomic acid such as hydrochloric acid.[1] The experiments described in the present paper were made, at Prof. MacGregor's suggestion, in order to ascertain if it is possible to make the prediction in the case of solutions formed by mixing hydrochloric and sulphuric acid solutions.

The attempt to calculate the conductivity of a complex solution containing sulphuric acid as one constituent is of special interest because of the fact that it is supposed to have a mode of ionization which varies with the concentration of the solution, its molecules in dilute solutions dissociating into 2 H and SO_4, but in stronger solutions partly into H and H SO_4. It is of course impossible to calculate the conductivity of a complex solution, one of the constituents of which has a mixed mode of ionization. I have therefore assumed that the mode of ionization in the moderately dilute solutions which I examined would be the same as it is usually supposed to be at great dilution.

The conductivity of a mixture of two solutions of electrolytes 1 and 2, with a common ion and definite modes of ionization

---

[1] MacGregor: Trans. N. S. Inst. Sci., 9, 101, 1895-6.
McIntosh: *Ibid.*, 9, 120, 1895-6.
Archibald: *Ibid.*, 9, pp. 291, 307, 1897-8.
McKay: *Ibid.*, 9, 321, 1897-8.
Barnes: *Ibid.*, 10, 49, 1898-9.

is given, according to the dissociation theory, by the equation:

$$k = \frac{1}{p(v_1 + v_2)}\left(a_1 v_1 n_1 \mu_{\infty 1} + a_2 v_2 n_2 \mu_{\infty 2}\right), \ldots (A)$$

where v_1, v_2 are the volumes, and n_1, n_2 the concentrations of the solutions mixed, $\mu_{\infty 1}$, $\mu_{\infty 2}$ the specific molecular conductivities of simple solutions of the electrolytes at infinite dilution, a_1 and a_2 the ionization co-efficients of the respective electrolytes in the mixture, and p the ratio of the volume of the mixture to the sum of the volumes of the constituent solutions.

[1] Prof. MacGregor has shown that the ionization coefficients in a mixture of this kind may be found by the solution of four equations, and I have pointed out in a former paper[2] that by throwing these equations into other forms and applying a graphical method they may be solved with little trouble, even in cases in which but few observations of the conductivity of simple solutions of the electrolytes in the mixtures are available. The forms of the equations referred to are as follows:

$$k_1 = \frac{\mu_{\infty 1}}{\mu_{\infty 2}} k_2,$$

$$\frac{N_1}{C_1} + \frac{N_2}{C_2} = 1,$$

$$k_1 = f_1(C_1),$$

$$k_2 = f_2(C_2),$$

where the k's and C's are the regional conductivities and regional concentrations, and the N's the concentrations of the mixture, with respect to the electrolytes 1 and 2 respectively. By the regional conductivity and the regional concentration of an electrolyte in a mixture are meant the conductivity and concentration of the portion or region of the mixture which the one electrolyte may be supposed to occupy to the exclusion of the other. If there is no change of volume on mixing, they are the conductivities and concentrations of the isohydric constituents of the mixture.

[1] Trans. N. S. Inst. Sci., 10, 68, 1898-9.
[2] Trans. N. S. Inst. Sci., 10, 113, 1899-1900.

The method of obtaining the ionization coefficients by means of these equations is described in my former paper, the first stage in the process being the determination of the k's and C's. In the calculation of the conductivity, however, we save labour if instead of determining the ionization coefficients, we express the conductivity in terms of the k's and C's.

For this purpose we have:

$$a_1 = \frac{k_1}{C_1 \mu_{\infty 1}},$$

and

$$a_2 = \frac{k_2}{C_2 \mu_{\infty 2}}.$$

Equation (A) thus becomes:

$$k = \frac{1}{p(v_1 + v_2)} \left(\frac{k_1 n_1 v_1}{C_1} + \frac{k_2 n_2 v_2}{C_2} \right).$$

In my experiments p was found to be practically equal to unity, and the volumes of the solutions mixed were in all cases equal. Hence the above equation becomes:

$$k = \tfrac{1}{2} \left(\frac{k_1 n_1}{C_1} + \frac{k_2 n_2}{C_2} \right) \ldots\ldots\ldots\ldots\ldots\ldots \text{(B)}$$

The work involved in finding k by means of equation (B), included the following:—(1) The preparation and analysis of series of simple solutions of both acids, and the preparation of the mixtures; (2) observations on the specific gravity of the simple constituent solutions and their mixtures; (3) the measurement of the conductivity of series of simple solutions; (4) the measurement of the conductivity of mixtures of solutions; (5) the determination of the regional conductivity and regional concentration of the electrolytes in the mixtures; (6) the calculation by the aid of these data, of the conductivity of the mixtures.

The observations were carried out in the Physical and Chemical Laboratories of Dalhousie College, Halifax, during the spring and autumn of 1899.

Experimental Methods.

The hydrochloric acid was obtained from Eimer & Amend, and the sulphuric from Merck & Co. Both were guaranteed chemically pure. The redistilled water used in the preparation of the solutions was obtained by the method described in a former [1]paper, and it had a conductivity ranging from 0.95×10^{-6} to 1.01×10^{-6} expressed in [2]Kohlrausch's new unit (ohm^{-1} $cm.^{-1}$).

The amount of hydrochloric or sulphuric acid in a solution was determined volumetrically by means of aqueous solutions of potassium hydroxide, the strength of these being determined daily by titration with known quantities of dry oxalic acid. Phenol-phthalein was the indicator used. The potassium hydroxide solutions were kept in bottles with stoppers, each containing a soda lime tube. The pipettes, burettes and flasks were calibrated and used as described in the paper referred to above. The specific gravity at 18°C. was determined for many of the simple solutions with a pyknometer of the Ostwald-Sprengel form. The comparison of the values thus obtained with the values as given by Kohlrausch, acted as a check upon the concentration as determined above.

Kohlrausch's method with the alternating current and telephone was employed in the measurement of the conductivity.

The bath used to obtain a constancy of temperature, for a time sufficient to make the determination of the resistance in, contained tap water kept continually stirred by a mechanical stirrer driven by one of Henrici's small hot air motors. This motor worked without noise and on this account was found more serviceable than the hydraulic motor formerly employed. The thermometer used could be read to a hundredth of a degree, and had been tested at the Physikalisch-Technische Reichsanstalt, Berlin.

The resistance of the solutions was measured in a U-shaped cell having electrodes of stout platinum foil connected by thick

[1] Trans. N. S. Inst. Sci., 10, 49, 1898-9.

[2] Kohlrausch u. Holborn: Leitvermögen der Elektrolyte, 1898, p. 1.

platinum wires to the ebonite covers. These electrodes were platinized in the solution proposed by [1]Lummer and Kurlbaum. The reduction factor by which the conductivities obtained in this cell are reduced to the standard employed by Kohlrausch, was obtained by comparing the value of the conductivities of two solutions of pure potassium chloride, twice recrystallized, of different concentrations, with values given by [2]Kohlrausch for the same concentrations of the same salt. The ratio of Kohlrausch's value to the observed value gives the reduction factor. It was always determined before and after a series of observations, and was found to be the same in value at both times.

Solutions of different concentrations of each acid were prepared and carefully analysed. Fifty cubic centimetres of one of these solutions was placed in the electrolytic cell at a time, and two successive dilutions prepared in the cell by the addition of known volumes of water at 18°C. Then the other prepared solutions were introduced in order, and the same process of dilution repeated till a sufficient number of conductivity values had been obtained. In the case of mixtures, equal volumes (fifty cubic centimetres) of the constituent solutions were mixed at 18° C., and the mixture was then placed in the cell.

For a more detailed description of some of the above instruments and methods, see my former paper on conductivity.

Results of the Conductivity Observations on Simple Solutions.

It is necessary for the determination of the regional conductivities (k) and the regional concentrations (C) in the mixture (see my former paper),[3] to draw curves showing the relation of conductivity to the concentration for each acid. In the case of one of the electrolytes, (hydrochloric acid was selected), the values of the conductivity must be multiplied by a constant before plotting, this constant being the ratio of the specific molecular conductivities at infinite dilution for the two

[1] Wied. Ann., 66, 315, 1897.
[2] Kohl. u. Holb., *loc. cit.*, p. 159, tab. 2.
[3] Trans. N. S. Inst. Sci., 10, 113, 1899-1900.

acids. Kohlrausch's latest determinations[1] of the values of the specific molecular conductivity at infinite dilution at 18° C. for the two acids were used, viz.: for hydrochloric acid, 3774, and for sulphuric acid, 3955, both expressed in terms of 10^{-4} times Kohlrausch's new unit (ohm^{-1} $cm.^{-1}$). Therefore, the ratio is 1.048.

Table I gives the data, obtained from the conductivity observations, for the drawing of these curves. The concentrations are expressed in terms of gramme equivalent per litre at 18°C. The atomic weights used are relative to Oxygen (16.00), and the same as employed by [2]Kohlrausch. The specific conductivities are those at 18°C, expressed in terms of 10^{-4} times Kohlrausch's new unit (ohm^{-1} $cm.^{-1}$).

TABLE I.

H Cl. (36.46.)			½ H_2 SO_4. (49.04.)	
Concentration (n_1).	Specific Conductivity (k_1).	$\frac{\mu\infty_2}{\mu\infty_1}k_1$	Concentration (n_2).	Specific Conductivity (k_2).
2.66	6018.	6305.	4.11	6158.
2.13	5281.	5534.	2.95	4948.
1.74	4627.	4848.	2.20	3947.
1.42	3994.	4185.	1.74	3255.
1.02	3055.	3201.	1.28	2472.
.716	2268.	2376.	.890	1779.
.502	1640.	1718.	.523	1070.
.344	1148.	1203.	.452	932.5
.265	898.3	941.2	.304	637.4
.188	645.3	676.2	.197	421.8
.126	439.7	460.8	.108	241 5
.0951	334.9	350.9	.0967	218.8
.0810	287.9	301.6	.0603	148.4
.0559	201.0	210.6	.0352	93.77
.0356	129.3	135.5	....	....
.0262	94 67	99.20	....	....

[1] Wied. Ann., 50, 385, 1893.

[2] Kohl. u. Holb., *loc. cit.*, p. 205, tab. 14.

Determination of p.

When equal volumes of simple solutions are mixed the ratio expressed by p is equal to the ratio of the specific gravity of the mixture to the mean specific gravity of the constituent solutions. Table II shows that the ratio is practically equal to unity for the most concentrated solutions examined.

TABLE II.

Simple Solutions.					Sp. Gr. of Mixture at 18°C.
Concentration.		Specific Gravity at 18°C.		Mean Sp. Gr.	
H Cl.	$\frac{1}{2} H_2SO_4$.	H Cl.	$\frac{1}{2} H_2SO_4$.		
3.05	2.95	1.0525	1.0912	1.0719	1.0720
2.13	1.74	1.0371	1.0549	1.0460	1.0462
1.02	"	1.0182	"	1.0366	1.0365
.502	"	1.0091	"	1.0320	1.0319

Results of the Observations and Calculations of the Conductivity of Mixtures.

Table III contains the results of the observations and the calculations, by means of the data given therein, of the conductivity of mixtures of the acids under consideration. The regional concentration k_1 of the hydrochloric acid may be obtained from the value k_2 by means of the expression

$$k_1 = \frac{\mu_{\infty 1}}{\mu_{\infty 2}} k_2,$$

where k_2 is the regional concentration of the sulphuric acid. The specific molecular conductivities at infinite dilution have the values given above. In this table the conductivities and concentrations are expressed as in Table I. The differences between the calculated and observed values of the conductivity are given as percentages of observed values.

TABLE III.

Concentrations, Constituent Solutions.		Regional Conductivity of $\frac{1}{2}H_2SO_4$ (k_2).	Regional Concentrations.		Specific Conductivity of Mixture.		Difference Per Cent.
H Cl. (n_1).	$\frac{1}{2}H_2SO_4$ (n_2).		H Cl. (C_1).	$\frac{1}{2}H_2SO_4$ (C_2).	Calculated Value.	Observed Value.	
3.80	2.95	6522.	2.83	4.50	6324.	6252.	+1.15
3.05	"	6013.	2.44	3.95	5840.	5784.	+ .97
1.74	"	4905.	1.77	2.92	4786.	4763.	+ .48
.0810	"	2948.	.925	1.55	2938.	2918.	+ .70
.804	.917	2240.	.669	1.15	2178.	2169.	+ .41
.328	"	1495.	.432	.739	1469.	1464.	+ .34
.0521	"	1036.	.292	.503	1033.	1035.	— .19
1.64	.291	2910.	.907	1.53	2788.	2779.	+ .32
1.02	"	2018.	.596	1.02	1936.	1934.	+ .10
.804	"	1668.	.487	.831	1606.	1607.	— .06
.328	"	886.0	.249	.429	857.3	856.7	+ .07
.0810	"	459.1	.125	.215	452.7	454.7	— .44
1.74	.0352	2832.	.880	1.48	2705.	2704.	+ .04
.502	"	927.8	.261	.450	888.0	889.6	— .18
.0951	"	219.2	.0581	.0967	211.1	211.8	— .33
.0810	"	194.7	.0515	.0823	187.8	188.3	— .27
.0521	"	143.1	.0376	.0575	138.4	138.5	— .08
.0264	"	96.65	.0256	.0363	94.43	94.54	— .12

In this table it will be noticed in the first series of observations, where the concentration of the constituent solution of sulphuric acid is constant, while the constituent solution of hydrochloric acid has a variable concentration, that the calculated values are all greater than the observed, and that the differences gradually increase as the concentration of the hydrochloric acid increases. This is also true for the second and third series, except in the case of the weaker hydrochloric acid solutions where the calculated is now less than the observed value. Prof. MacGregor has shown in a note to my former [1]paper, in which I drew attention to a regular progression similar to the above for series of solutions of potassium chloride and potassium sulphate, which were for the most part of moderate concentration, that the regular progression observed may be due to two sources of error. The second source, namely, the impossibility of drawing with perfect accuracy the dilution-ionic-concentration curves, has, I think, been considerably reduced, for in place of drawing these curves, which for moderate concentration curve quite rapidly, concentration-specific-conductivity curves were employed, these curves having but slight curvature and being thus easily interpolated. The other source of error, namely, the using for the value of the ionization coefficient the quotient of the specific molecular conductivity by the specific molecular conductivity at infinite dilution, still remains. In the above fourth series where the first two mixtures are of moderate concentration and the other four may be called dilute solutions, this regular progression has disappeared and the differences are all negative, except in the first mixture. The disappearance of the progression is consistent with its being due to the above sources of error; for in dilute solutions they both produce a very small effect upon the result. Two reasons may be assigned for the signs being all negative in the fourth series:—(1) The use of the above values of the specific molecular conductivity at infinite dilution; for if either of the values used should not be correct then it would clearly produce an error of the same sign

[1] *Loc. cit.*

in all the calculated values of the conductivity. There is also (2) the possibility referred to above, of the sulphuric acid breaking up not only into ions of 2 H and SO_4, but also into H and H SO_4.

It is also possible by plotting the above series to obtain series of mixtures having a constant concentration for the constituent hydrochloric acid solutions and variable concentrations for the sulphuric acid constituent solutions; and it will be found in series of this kind that the same regular progression is exhibited as in the above. It may be well to note that in the last three series of the above Table where the sign of the difference changes, this change happens for all when the average concentration of the mixture is about 0.6 gramme-equivalents.

Finally, since my experiments are estimated as affected by an error which may amount to about ± 0.3 per cent., it is seen in the table that as the differences for the three last series are all within or in a few cases but little beyond this error, it may be concluded that the conductivity of mixtures of dilute solutions of hydrochloric and sulphuric acid can be calculated within the limit of my experimental error, by the expression of the dissociation theory and on the assumption that the sulphuric acid dissociates into 2 H and SO_4 as ions, up to an average concentration of about 0.5 in cases in which the concentration with respect to sulphuric acid is relatively large, and up to an average concentration of about 0.9 in cases in which the concentration with respect to this acid is relatively small.

III.—On the Depression of the Freezing-Point by Mixtures of Electrolytes.—By James Barnes, B. A., *Dalhousie College, Halifax, N. S.*

(Communicated by Professor J. G. MacGregor on March 12th, 1900.)

In a [1] paper communicated last winter to this Society, Mr. E. H. Archibald described experiments he had made to test the ionization coefficients, obtained by [2] Prof. MacGregor's method, for mixtures of equimolecular solutions of two electrolytes having an ion in common. With these coefficients and Van't Hoff's constant as data, he calculated the depression of the freezing-point of the mixtures; and he then compared the calculated with the experimental values. It was found that the difference between these values was, in general, equal to the arithmetic mean of the differences between the calculated and experimental values of the depressions of the constituent simple solutions, and the test was therefore concluded to be satisfactory.

At Prof. MacGregor's suggestion, I undertook similar experiments with mixtures, not of equimolecular solutions, but of solutions of different concentrations. The electrolytes selected were potassium chloride, sodium chloride, and hydrochloric acid.

In the case of mixtures of solutions which are not equimolecular Mr. Archibald's method of testing the ionization coefficients is not applicable. I found it necessary, therefore, to obtain an expression for the depression of the freezing-point for such mixtures in terms of the ionization coefficients.

In a simple solution containing n gramme-molecules of an electrolyte per litre, if a is the ionization coefficient, the number of dissociated molecules is $n\,a$ and the number of undissociated $(1-a)\,n$. If a molecule of this electrolyte breaks down

---

[1] Trans. N. S. Inst. Sci., 10, 33, 1898-99.

[2] *Ibid.*, 9, 101, 1895-96.

into m ions, then the number of free ions is $n\,m\,a$, and therefore the total number of undissociated molecules and free ions in this solution is

$$(1-a)\,n+n\,m\,a, \quad \text{or} \quad n\Big(1+a\,(m-1)\Big).$$

On the assumption that a free ion produces the same amount of depression of the freezing-point as a molecule, and that in a solution the molecules are so far apart that no association of molecules occurs, if δ is the depression of the freezing-point and M the molecular depression, *i. e.*, the depression produced by one gramme-molecule or one gramme-ion, we have

$$M = \frac{\delta}{n\,\big(1+a\,(m-1)\big)} \quad \cdots\cdots\cdots\cdots\cdots\cdots (1)$$

In the case of mixtures of simple solutions, according to the above assumption, $\triangle$ the depression of the freezing-point will be represented by the expression :—

$$\triangle = \Big[M_1N_1\Big(1+a_1(m_1-1)\Big)+M_2N_2\Big(1+a_2(m_2-1)\Big)+\ldots\Big] . (2)$$

where 1, 2, etc., denote the electro ytes, the m's the numbers of ions into which the molecules of the respective electrolytes break down, the a's the ionization coefficients in the mixture, the N's the concentrations (in gramme-molecules per litre) of the mixture with respect to the respective electrolytes, and the M's the depressions produced by one gramme-molecule or one gramme-ion of the undissociated and dissociated portions respectively of the electrolytes. The a's in this expression are given by the method to be tested; the m's in the case of the electrolytes selected can have only one value; and the N's are of course known; but what values the M's are to be regarded as having is doubtful. It was found for simple solutions of the three electrolytes employed, that the molecular depressions increased as the solutions became more concentrated. This appears to indicate that one molecule or one ion, when in the presence of a large number of molecules and ions, produces a greater depression than when it is in the presence of a smaller number. Thus in the case of a solution made by mixing simple solutions of different electrolytes, since the number

of molecules and ions present seems to affect the power which one molecule or ion has of lowering the freezing-point, it was assumed that the depression produced by a molecule or an ion of say, the electrolyte 1, which is surrounded by molecules and ions of this electrolyte 1 and of the other electrolytes 2, 3, etc., would have the same value as if all the molecules and ions surrounding it were of electrolyte 1. Thus the M's of the above expression have been regarded as equal to the molecular depressions in simple solutions of the concentration $N_1 + N_2 +$ etc.

The application of this expression to the calculation of the depression in mixtures will form at once a test of the above assumption and a test of the ionization coefficients employed. I have applied it (*a*) to mixtures of potassium chloride and sodium chloride, these salts being selected because of their simple molecular structure and the approximate equality in their grade of ionization; (*b*) to mixtures of sodium chloride and hydrochloric acid, selected because of their simple molecular structure and the considerable difference in their grade of ionization; (*c*) to mixtures of potassium chloride, sodium chloride and hydrochloric acid, selected for testing in addition the method of finding the ionization coefficients in a mixture of three electrolytes.

The following is a synopsis of the work involved:—Purification of materials;—construction and calibration of the instruments used in the conductivity and freezing-point observations;—preparation and analysis of a series of simple solutions of the three electrolytes;—determination of the specific molecular conductivities at infinite dilution for 0°C.;—observations on the conductivity at 0° for the series of simple solutions;—calculation of the ionization coefficients at 0° from the conductivity observations;—measurement of the depression of the freezing-point of the simple solutions;—calculation of the molecular depression for each solution of the three electrolytes;—preparation of mixtures of two and of the three electrolytes;—measurement of the depression of the freezing-point of the mixtures;—

determination of the ionization coefficients of the electrolytes in the mixtures;—calculation of the depression of the freezing-point in the mixtures.

The experiments were carried out during the session of 1899-1900 in Dalhousie College, Halifax.

Materials, Apparatus and Methods.

The salts and acids were obtained from Merck. The salts were recrystallized once, and it was found that solutions of them, and also of the acid, had conductivity values showing satisfactory agreement with the values as given by [1] Kohlrausch. These electrolytes were therefore considered sufficiently pure for the purpose. The water used in making the solutions was purified by the method described in my former [2] paper, and it had a conductivity at 18°C. of about 0.95×10^{-6} expressed in terms of Kohlrausch's new [3] unit (ohm^{-1} $cm.^{-1}$).

The solutions of potassium and sodium chloride were prepared by direct weighing; the salts being first dried to constant weight in an air-bath. The hydrochloric acid solutions were analysed volumetrically by means of a standardized solution of potassium hydroxide with phenol-phthalein as indicator. All burettes and pipettes used in the preparation and analysis of these solutions were calibrated by the weight of distilled water they delivered, and the flasks by the weight of water they held at 0°C.

Observations were made on the specific gravity at 18°C. of the simple solutions and their mixtures with a pycnometer of the Ostwald-Sprengel form. These observatious were made to obtain the knowledge whether or not there was any change of volume on mixing the simple solutions. It was found that with solutions of the concentrations used, there was no appreciable change, and it was assumed that such would also be the case at 0°.

---

[1] Kohlrausch u. Holborn: Leitvermögen der Elektrolyte, 1898, pp. 159, 160, tab. 2.
[2] Trans. N. S. Inst. Sci., 10, 49, 1898-99.
[3] Kohl. u. Holb., *loc. cit.*, p. 1.

Conductivities were determined by Kohlrausch's method with the alternating current and telephone. The Wheatstone's bridge consisted of four coils, two of which, the 100 and 1000 ohms, were the only ones used. These coils were correct at 17.5°C. and had a temperature coefficient of 0.000267 per centigrade degree per ohm. The correction for temperature was applied when the observations were made in the basement room referred to below. The platinoid bridge wire was calibrated by the method proposed by [1] Strouhal and Barus with ten german silver wires of equal length. A telephone made by Ericsson of Stockholm, and an inductorium made after a plan of Ostwald's and giving a clear high note were employed. For a detailed account of the pycnometer, and of the instruments employed in the conductivity observations, with the methods used, see my paper referred to above.

Three electrolytic cells of two types were used. One, with the shape of a U-tube, was employed for the stronger solutions of the hydrochloric acid. The other two were of the Arrhenius form. One of these, with electrodes at a distance from one another of about $\frac{1}{2}$ cm., was used for the weak solutions employed in the determination of the specific molecular conductivities for 0°C.; the other with electrodes at a distance of about 5 cm., for the stronger solutions of the two salts. The electrodes were all of stout platinum foil firmly fixed to the platinum wire and glass connections, so that the capacity of the cell once determined would remain the same throughout a series of experiments. These electrodes were platinized in a solution prepared from [2] Lummer and Kurlbaum's recipe. The reduction factor of each of these cells, by which the observed conductivities were reduced to the standard employed by Kohlrausch, was obtained by comparing the values determined for two carefully prepared solutions of potassium chloride, with the values given by [3] Kohlrausch for the same concentrations. Data for the

---

[1] **Wied. Ann., 10, 326, 1880.**
[2] **Wied. Ann., 60, 315, 1897.**
[3] **Kohl. u. Holb., *loc. cit.*, p. 159, tab. 2.**

determination of the reduction factors were available only at 18°, but as the cell was of glass its value at 0° would not be practically different from that at 18°.

The water bath used in the observations of the conductivity at 18° was the same as that described in my former paper. In the case of the observations at 0° the bath was modified so that the temperature could be kept constant at 0° by means of pieces of ice floating in it, while the water was kept continually stirred. The ice was prevented from coming in contact with the cell by placing around the cell a cylindrical screen of wire gauze 17 cm. in diameter, and reaching to within 10 cm. of the bottom of the bath. By the addition or the removal of pieces of ice from the salt water, the temperature of the bath could easily be kept within one twenty-fifth of a degree for a sufficient time to make the measurement of conductivity. The observations were made in a basement room of the college, where the temperature, during the winter months, was generally below 6°C. The thermometer used was graduated to a fiftieth of a centigrade degree and its zero point was determined by the writer. Each solution was brought to about 0° before it was placed in the cell, and while in the cell successive observations of the conductivity were made to insure that the temperature of the bath had been taken.

The method employed for finding the freezing-point of the solutions was the same in principle as that proposed by [1] Loomis The size of the protection bath was larger than that used by Loomis, and the stirring was done mechanically.

The thermometer used was of the Beckmann form. It was graduated to a hundredth of a degree, and could be read to a thousandth by aid of a small microscope, mounted on an upright stand. This thermometer was at a certain place on its stem firmly fixed in the cork of the inner freezing-tube (the freezing-tubes consisted of an inner and outer tube, the inner containing the solution whose freezing-point was measured) so that when in position its bulb was within 2 cm. of the bottom of the tube.

[1] Phys. Review, 1, 199, 1893 and 9, 257, 1897.

This inner freezing-tube was 28 cm. in length and 2.8 cm. in diameter and had its lower end re-entrant. The outer tube was 25 cm. in length and 3.15 cm. in diameter. The thickness of the glass being about 1 mm., there was an air space of about 1.5 mm. between the tubes. This space was found to be quite sufficient to prevent the formation of ice on the wall of the tube. The inner tube was supported in the outer by means of two rubber bands, one at the top and the other at the bottom. These bands also prevented the walls from touching one another. The length of the tubes allowed the solution to be well submerged in the protection bath and therefore almost freed it from the influence of the outside temperature.

In the determination of the freezing-point of a solution these tubes were surrounded by a mixture of salt water and pieces of ice, contained in a vessel of glass 35 cm. high and 11 cm. in diameter (called the protection bath). The cover for this vessel was one taken from the protection bath of a Beckmann apparatus. The glass of this vessel was $\frac{1}{2}$ cm. thick and was covered with asbestos paper that the effect of the temperature of the room might be lessened. It was found necessary to keep this bath at a constant temperature within a fiftieth of a degree, if values of the freezing-point agreeing with the mean value to less than a thousandth of a degree were desired. This was obtained by keeping the bath continually stirred. Any change of temperature was quickly recorded by means of a thermometer graduated to a fiftieth of a degree. The temperature of the bath could be raised by the addition of water at the temperature of the room, or lowered by the addition of pieces of ice, snow when obtainable being preferable.

The platinum stirrer for the freezing-tube was of the common ring shape, having wound around its ring a thin platinum wire, which would rub against the wall of the tube and thereby prevent the formation of an ice sheath. With constant stirring there was found no tendency for the ice to mass itself together and float to the surface, but it could be seen moving through the whole solution in tiny glistening particles. The stirrer for the

protection bath was of thick brass wire with two rings, one for the upper aud the other for the lower portion. Both these stirrers were worked mechanically by means of one of Henrici's hot air motors placed at a distance of about 3 metres from the freezing-point apparatus. By means of a light belt this motor turned a small wooden wheel placed over the protection bath. A connecting-rod connected this wheel to a slider on a vertical guiding rod; and to this slider also were attached the two stirrers. Any range of stroke could be obtained by varying the distance of the connecting-rod from the centre of the wheel. As about 70 cc. of solution were used, a stroke of 11 cm. was required to cause the ring of the stirrer in the freezing-tube just to touch the bottom of the tube and reach to within $\frac{1}{2}$ cm. of the surface of the solution. Thus all solutions were throughout uniformly stirred, and as the stroke of the engine was quite constant every solution was stirred in exactly the same manner.

Another glass vessel of the same dimensions as the protection bath contained salt water and ice at a temperature of about — 10°C. (called the freezing bath). The purpose of this bath was to reduce the solution in the freezing-tube to about 0.3 degree below the freezing-point.

The hammer of a common electric bell covered with a piece of rubber tubing, and supported on a frame over the freezing-point apparatus, was used for tapping the thermometer. A current from an Edison-Lalande cell had sufficient strength to give rapid and vigorous blows.

The following method of [1] Raoult's was employed for determining the elevation above the temperature of the protection bath, of the convergence temperature of this apparatus, *i. e.*, the temperature finally assumed by a solution which is being stirred and has no ice in it, when it comes into thermal equilibrium with the protection bath. The freezing-point of water was first obtained. The ice formed in this observation was then melted and the freezing-tubes containing the water returned to the protection bath and the stirring begun. With the protection

[1] Ztschr. f. Phys. Chem., 27, 636, 1898.

bath kept constantly at 0° the temperature of the water in the freezing-tubes at first fell rapidly, then more slowly, till it remained constant at 0.05°. This experiment was repeated with the same result, and thus the convergence temperature was shown to be 0.05 degree above the temperature of the protection bath. In all experiments, therefore, the temperature of the protection bath was adjusted so as to be 0.05 degree below the freezing-point of the solution. It was also found with water that the protection bath required to be this same amount (0.05 degree) below the freezing-point in order that the value of the freezing-point, with a very small quantity of ice present, might agree with that obtained with a large amount of ice.

The method of carrying out an observation of the freezing-point was as follows:—The freezing-tube was filled with the solution up to a mark on the glass (about 70 cc.) It was then placed in the freezing bath where it remained till the temperature was lowered with constant stirring to about 0.3 degree below the freezing-point of the solution, this point having been determined by a preliminary experiment. The freezing-tubes were now quickly removed to the protection bath which was at the required temperature (0.05 degree below the freezing-point of the solution), and the stirring started. After ten minutes time, in which the solution had risen to within 0.1 degree of its freezing-point, a small crystal of ice was introduced through a glass tube in the cork. As the particles of ice gradually formed throughout the solution the mercury in the thermometer rose, and in about a minute assumed a fixed position. The tapping was begun and continued for half a minute when both it and the stirring were stopped, the microscope brought into position and a reading made. After again stirring and tapping, the thermometer was read again, this reading acting as a check upon the former. Care was taken to keep the protection bath constant at the required temperature throughout both these readings. The tubes were now removed, the ice melted, and the same operation repeated for a second observation.

As a change in the atmospheric pressure would cause a corresponding change in the thermometer, the freezing-point of the water used was determined about every three hours. The temperature of the room was kept as low and as constant as possible during the experiments, and no observation was made when it was above 5°C.

Since the freezing of my solutions was started about 0.1 degree below the freezing-point, the amount of ice formed was so small that the correction usually applied for the change in concentration, and, therefore, in the depression, comes within my limit of error. Thus the results are recorded without any correction.

Simple Solutions.

With the electrolytes K Cl, Na Cl, and H Cl, there is only one possible way for their molecules to dissociate, namely, into two ions. Hence expression (1) reduces to

$$M = \frac{\delta}{n\,(1+a)} \cdots\cdots\cdots\cdots (3)$$

For the determination of the values of M, the other quantities, δ, n and a are obtained from observations on simple solutions; a being taken equal to the ratio of the specific molecular conductivity to the specific molecular conductivity at infinite dilution. As the solutions are at a temperature of about 0°C. in the determination of the freezing-point, the ionization coefficients should be obtained at approximately the same temperature. For this purpose measurements were made of the conductivity at 0°, both of solutions of the range of concentration used in the observations of the freezing-point and also of very dilute solutions of the electrolytes. These latter measurements are required for the determination of the specific molecular conductivities at infinite dilution for 0°C.

Determination of the Specific Molecular Conductivities at Infinite Dilution for 0°C.

A series of simple solutions varying in concentration from .01 to .0001 in the case of the salts, and from .01 to .001 for the

acid, were prepared and their conductivities measured at 18° and at 0°. The conductivity of the water used in the preparation of these solutions was measured at both temperatures, and its value substracted in each case from the conductivity of the solution. Considerable care was required with these dilute solutions to obtain good results. The electrodes were thoroughly washed with a portion of the solution before placing them in the cell. Both the solutions and the water used were exposed as little as possible to the air, and the measurements were taken immediately after a solution was made. The measurements were repeated three times, and the mean of the values obtained was taken as the most probable value.

The following Table I gives the values thus obtained, and the ratio $\frac{\mu_{18}-\mu_0}{\mu_{18}}$, where μ_{18} and μ_0 are the specific molecular conductivities at 18° and 0° respectively. The concentrations are expressed in gramme-molecules per litre at 0°, and the specific molecular conductivities in terms of this unit and of 10^{-4} times Kohlrausch's new unit of conductivity.

TABLE I.

Concentration.	Sp. Mol. Cond. at 18°C. (μ_{18}).	Sp. Mol. Cond. at 0°C. (μ_0).	$\frac{\mu_{18}-\mu_0}{\mu_{18}}$.
	K Cl. (74.59).		
.010	1224	775	.367
.005	1244	787	.367
.001	1278	809	.367
.0005	1284	814	.366
.0002	1293	821	.365
.0001	1298	824	.365
	Na Cl. (58.50).		
.010	1028	638	.379
.005	1049	651	.380
.001	1075	664	.382
.0005	1084	670	.382
.0002	1094	676	.382
.0001	1098	679	.382
	H Cl. (36.46).		
.010	3706	2595	.300
.005	3731	2608	.301
.002	3753	2625	.301
.001	3757	2626	.301

The ratio $\frac{\mu_{18}-\mu_0}{\mu_{18}}$ appears to increase as the concentration diminishes, except in the case of potassium chloride where it decreases. This peculiarity is also shown in the values as calculated by means of [1] Déguisne's data. The agreement between Déguisne's conductivity values at 0° and the above for the solutions of concentration .01 is very close, but with the dilute solutions it is not so good. It was found impossible to obtain

[1] Kohl. u. Holb., *loc. cit.*, p. 199, tab. 7.

concordant results with solutions of greater dilution than those above. It is seen, however, that the ratio appears to reach a constant value in these dilute solutions, and the writer has assumed that the value of this ratio for the solution of concentration .0001 of the salts and .001 of the acid would hold for infinite dilution.

Table II gives the values of the specific molecular conductivities at infinite dilution for 0° obtained from Kohlrausch's values at 18° by aid of the above ratios. The conductivities are expressed as in Table I.

TABLE II.

Electrolyte.	Specific Molecular Conductivity at Infinite Dilution.	
	For 18°C.	For 0°C.
K Cl	[1]1312	833
Na Cl	[1]1103	682
H Cl	[2]3774	2638

Determination of the Ionization Coefficients at 0°C. for Simple Solutions.

For this purpose the specific conductivities at 0°C. for series of simple solutions of each electrolyte were found. These conductivity values are also necessary for the drawing of the curves showing the relation between the concentration and the conductivity; these curves being required in the determination of the ionization coefficients in the mixtures.

Table III contains the observed values and also the ionization coefficients calculated therewith. The concentrations are expressed in gramme-molecules per litre at 0°C., and the conductivity in terms of 10^{-4} times Kohlrausch's new unit.

[1] Kohl. u. Holb., *loc. cit.*, p. 200, tab. 8.
[2] Wied. Ann., 50, 385, 1893.

TABLE III.

Concentration. (n).	Specific Conductivity at 0°C. (k).	Ionization Coefficients at 0°C. (a).
	K Cl.	
.03	22.73	.910
.05	37.15	.892
.08	58.32	.875
.10	71.83	.862
.20	138.5	.832
.30	204.5	.819
.40	268.1	.804
	Na Cl.	
.03	18.34	.896
.05	29.92	.877
.08	46.93	.860
.10	58.03	.850
.20	111.2	.815
.30	161.0	.787
.40	208 9	.765
	H Cl.	
.03	76.43	.966
.05	126.1	.956
.08	198.9	.942
.10	246.1	.933
.20	480.3	.910
.30	710.6	.898
.40	933.4	.884

Determination of the Values of M.

The following Table IV contains the values of the depression of the freezing-point of the simple solutions. These values, being the means of three observations, are given to four places of decimals. It also contains the values of the lowering (M) produced by each gramme-molecule or gramme-ion of the electrolyte

in the solution, calculated by expression (3) with the data given in this Table and in Table III. The concentrations are expressed as in former tables and the depressions in centigrade degrees.

TABLE IV.

Concentration. (n).	Depression of Freezing-point. (δ).	Molecular Depression. (M).
	K Cl.	
.03	.1060	1.85
.05	.1752	1.85
.08	.2776	1.85
.10	.3458	1.86
.20	.6795	1.86
.30	1.0171	1.86
.40	1.3487	1.87
	Na Cl.	
.03	.1072	1.89
.05	.1768	1.88
.08	.2824	1.90
.10	.3515	1.90
.20	.6885	1.90
.30	1.0292	1.92
.40	1.3646	1.93
	H Cl.	
.03	.1078	1.83
.05	.1786	1.83
.08	.2835	1.83
.10	.3552	1.84
.20	.7138	1.87
.40	1.4553	1.93

By comparing Loomis' values of the depression of the freezing-point with these values, it will be seen, that the agreement in many cases is very close. If both results are plotted the curve, formed by joining the points given by the above values,

will be a little above that obtained from Loomis' values. As mentioned above, the molecular depression increases as the solutions become stronger.

According to Van't Hoff's theory the value of the molecular depression should be 1.86. [1]Loomis found experimentally that, with a large number of non-electrolytes in aqueous solutions, the molecular depression was 1.86 for the dilute solutions. In the case of the electrolytes used above, with the ionization coefficients determined by the conductivity method, the values of the molecular depression are seen to be grouped around this value. The divergence from this value may partly be accounted for by the use of the doubtful values of the specific molecular conductivities at infinite dilution for 0°, employed in the calculations of the ionization coefficients.

Mixtures of Solutions of Two Electrolytes.

Since equal volumes of simple solutions of two electrolytes, having one ion in common, were mixed, and the molecules of the electrolytes used dissociate each into two ions, expression (2), as there was no change of volume on mixing, reduces to :

$$\triangle = \tfrac{1}{2}\left[M_1 n_1 (1 + a_1) + M_2 n_2 (1 + a_2)\right] \ldots\ldots\ldots (4)$$

in which n_1 and n_2 are the concentrations of the simple constituent solutions. For the calculation of $\triangle$ the depression of the freezing-point of the mixture by this expression, the n's are known, the a's are obtained by the modification of Prof. MacGregor's method fully described in my former [2] paper, and the M's in the manner referred to above.

Results of the Calculations.

Table V gives the data necessary for the calculation of the depression of the freezing-point of mixtures of potassium chloride and sodium chloride, and of sodium chloride and hydrochloric acid. It also shows the agreement of the calculated with the observed values. The concentrations, molecular depressions of the constituent solutions, and the depressions of the freezing-points of the mixtures are expressed as in Table IV.

[1] Phys. Review, 9, 257, 1899.
[2] Trans. N. S. Inst. Sci., 10, 124, 1899-1900.

TABLE V.

Concentrations, Constituent Solutions at 0°C.		Ionization Coefficients in Mixture at 0°C.		Molecular Depression in Mixture.		Depression of Freezing-point of Mixture.		Difference.
K Cl. (n_1).	Na Cl. (n_2).	K Cl. (a_1).	Na Cl. (a_2).	K Cl. (M_1).	Na Cl. (M_2).	Observed Value.	Calculated Value.	
.05	.03	.902	.886	1.85	1.89	.1406	.1415	+.0009
"	.06	.890	.878	1.85	1.89	.1942	.1937	–.0005
"	.08	.883	.866	1.85	1.90	.2283	.2289	+.0006
"	.10	.878	.863	1.85	1.90	.2648	.2638	–.0010
"	.20	.854	.834	1.86	1.90	.4361	.4345	–.0016
"	.40	.829	.807	1.86	1.90	.7709	.7716	+.0007
.30	.03	.840	.825	1.86	1.90	.5661	.5655	–.0006
"	.06	.838	.820	1.86	1.90	.6164	.6167	+.0003
"	.08	.835	.818	1.86	1.90	.6519	.6501	–.0018
"	.10	.833	.816	1.86	1.90	.6856	.6840	–.0016
"	.20	.827	.798	1.86	1.91	.8546	.8531	–.0015
"	.40	.813	.775	1.87	1.93	1.1924	1.1937	+.0013

TABLE V—(*Continued*).

Concentrations, Constituent Solutions at 0°C.		Ionization Coefficients in Mixture at 0°C.		Molecular Depression in Mixture.		Depression of Freezing-point of Mixture.		Difference.
Na Cl. (n_1).	H Cl. (n_2).	Na Cl. (a_1).	H Cl. (a_2).	Na Cl. (M_1).	H Cl. (M_2).	Observed Value.	Calculated Value.	
.05	.03	.883	.960	1.89	1.83	.1436	.1428	−.0008
"	.05	.877	.958	1.89	1.83	.1786	.1783	−.0003
"	.08	.866	.952	1.90	1.83	.2307	.2315	+.0008
"	.10	.860	.947	1.90	1.83	.2654	.2665	+.0011
"	.20	.836	.924	1.90	1.85	.4438	.4432	−.0006
"	.40	.800	.908	1.91	1.88	.8057	.8034	−.0023
.30	.03	.825	.919	1.90	1.86	.5752	.5738	−.0014
"	.05	.824	.919	1.90	1.86	.6103	.6090	−.0013
"	.08	.820	.919	1.90	1.87	.6617	.6624	+.0007
"	.10	.815	.918	1.90	1.87	.6984	.6967	−.0017
"	.20	.797	.907	1.91	1.89	.8748	.8755	+.0007
"	.40	.770	.894	1.93	1.93	1.2450	1.2436	−.0014

It is difficult to estimate the limit of error of the above observations. The observed values are in all cases means of at least three observations, which were found to differ from their mean values in different cases by very different amounts up to 0.001 degree. There are also many sources of error in the calculations and they do not admit of exact valuation. As a rough estimate the limit of error due to both observation and calculation may probably be put at 0.0015 degree.

If this estimate is approximately correct, the above table shows that the agreement between the observed and calculated values is very satisfactory for both mixtures of potassium chloride and sodium chloride, and of sodium chloride and hydrochloric acid.

Mixtures of Solutions of Three Electrolytes.

In the case of mixtures of the three electrolytes used as equal volumes of the simple solutions were mixed, and there was no change of volume on mixing, and as each molecule of these electrolytes breaks down into two ions, expression (2) becomes

$$\Delta = \tfrac{1}{3}\left[M_1\, n_1\,(1+a_1) + M_2\, n_2\,(1+a_2) + M_3\, n_3\,(1+a_2)\right] \quad \ldots . \ (5)$$

where the n's are the concentrations of the constituent solutions. Thus in any mixture the n's are known, the M's can be obtained as above, and the a's can be determined by the method given below.

Determination of the Ionization Coefficients in Mixtures of Three Electrolytes.

[1] Professor MacGregor has shown how to obtain equations sufficient for finding the ionization coefficients in a mixture of any number of electrolytes having a common ion, and how to solve them by a graphical procedure. As in the case of mixtures of two electrolytes,[2] I have, in the present case also, transformed

[1] Trans. Roy. Soc. Can. (2), 2, 69, 1896-97.
[2] Trans. N. S. Inst. Sci., 10, 124, 1899-1900,

Professor MacGregor's equations so as to express them in terms of regional conductivities and concentrations.

In the case of mixtures of three electrolytes the transformed equations are as follows :—

$$k_1 = \frac{\mu_{\infty 1}}{\mu_{\infty 2}} k_2 = \frac{\mu_{\infty 1}}{\mu_{\infty 3}} k_3, \ldots\ldots\ldots\ldots\ldots (6)$$

$$\frac{N_1}{C_1} + \frac{N_2}{C_2} + \frac{N_3}{C_3} = 1, \ldots\ldots\ldots\ldots (7)$$

$$\left.\begin{aligned} k_1 &= f_1 (C_1), \\ k_2 &= f_2 (C_2), \\ k_3 &= f_3 (C_3), \end{aligned}\right\} \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

where 1, 2, and 3 denote the electrolytes, the k's the specific conductivities of the electrolytes in the regions which they respectively occupy in the mixture, (these conductivities having the same values as in simple solutions of equal concentrations), the μ_∞'s the specific molecular conductivities at infinite dilution, the N's the concentrations of the mixture with respect to each electrolyte, and the C's the regional concentrations, which in the case of dilute solutions are the concentrations of the constituent isohydric solutions.

We have thus six equations for the determination of three k's and three C's.

These equations can be solved by a graphical process. In the first place the values of the specific conductivities of electrolyte 2, (k_2), are multiplied by the constant $\frac{\mu_{\infty 1}}{\mu_{\infty 2}}$, and those of electrolyte 3, (k_3), by $\frac{\mu_{\infty 1}}{\mu_{\infty 3}}$. Equations (8) are now employed by drawing curves having as abscissæ the values of the specific conductivities, and the corresponding values of the concentrations as ordinates. Three points are now found by inspection, one on each curve, having a common abscissa, according to equations (6),

and ordinates, (C_1, C_2 and C_3), whose values when substituted in equation (7), satisfy this equation. By this method we have found k_1, C C_2 and C_3; and k_2 and k_3 are easily obtained from equations (6). The a's, the ionization coefficients in the mixture, are then determined from the relation, $a = \frac{k}{\mu_\infty C}$.

Results of the Calculations.

The following Table VI contains the results of the calculations by expression (5); also the experimental values obtained for the depression of the freezing-point of mixtures of solutions of potassium chloride, sodium chloride and hydrochloric aid. The results in all the columns are expressed as in Table V.

TABLE VI.

Concentration, Constituent Solutions at 0°C. K Cl. (n_1).	Na Cl. (n_2).	H Cl. (n_3).	Ionization Coefficients in Mixture at 0°C. K Cl. (a_1).	Na Cl. (a_2).	H Cl. (a_3).	Molecular Depression in Mixture. K Cl. (M_1).	Na Cl. (M_2).	H Cl. (M_3).	Depression of Freezing-point of Mixture. Observed Value.	Calculated Value.	Difference.
.05	.06	.05	.890	.874	.962	1.85	1.89	1.83	.1878	.1892	+ .0014
"	.10	.08	.875	.860	.944	1.85	1.90	1.83	.2712	.2705	− .0007
"	.20	.10	.853	.838	.931	1.86	1.90	1.85	.4070	.4094	+ .0024
.30	.08	.10	.840	.825	.919	1.86	1.90	1.86	.5515	.5537	+ .0022
"	.10	.20	.833	.814	.913	1.86	1.90	1.87	.6952	.6943	− .0009
"	.20	.30	.821	.790	.904	1.86	1.91	1.89	.9290	.9274	− .0016

The calculated values in this Table will have a greater possible error than those in Table V, due to the greater number of experimental data required. In the observed values the possible error is the same as before. Considering the many sources of error in both these values the above agreement between them is very satisfactory.

Conclusions.

The above results show that in the case of mixtures of solutions of potassium chloride and sodium chloride, and of sodium chloride and hydrochloric acid, and of all three, it is possible, with the ionization coefficients obtained by the method referred to above, and on the assumption that the molecular depression of an electrolyte in a mixture is the same as it would be in a simple solution of the same total concentration, to predict the depression of the freezing-point within the limit of the error involved in observation and calculation.

IV.—On the Subdivisions of the Carboniferous System in Eastern Canada, with Special Reference to the Position of the Union and Riversdale Formations of Nova Scotia, referred to the Devonian System by some Canadian Geologists.—*By H. M. Ami, M. A., D. Sc., F. G. S., of the Geological Survey of Canada, Ottawa.*

(Read December 11th, 1899.)

Considerable discussion has arisen of late amongst European as well as North American geologists, as to where certain series of sedimentary strata occurring near the summit of the Palæozoic should be placed, either in the Carboniferous or in the Devonian system.

Whether certain other geological formations, occurring in the Maritime Provinces of Canada, should be described as Permian, or classed as Upper Carboniferous or Permo-Carboniferous, constitutes another problem. It is not within the province of this paper, however, at this time, to discuss this latter question, which it is hoped may form the subject of another paper before long.

Where to draw the line between the Carboniferous and Devonian systems in Eastern Canada, is therefore the question at issue. It is the purpose of the writer to enter this field of enquiry without any leaning or bias to any one view, but to take up the evidence as it presents itself to him and as it was collected by him during the last four years in the Counties of Pictou, Colchester, Cumberland, Antigonish, Hants, and Kings, in Nova Scotia, referring to such other localities and additional evidence only as the occasion may require.

Numerous and varied opinions have been given by many writers on this important question of the dividing line between the Devonian and the Carboniferous. These were consulted merely with the purpose of obtaining notes of records of observations that might help to throw light upon the problem, without

any prejudice or desire to accept one view or another, unless the facts adduced proved to be wholly reliable evidence.

Abram Gesner, Sir William Dawson, Sir Charles Lyell, Dr. Jackson, Prof. Alger, Prof. J. P. Lesley, M. de Koninck, M. de Verneuil, Mr. Hugh Fletcher, Dr. R. W. Ells, Mr. Henry S. Poole, Richard Brown, Prof. T. Rupert Jones, F. R. S., J. W. Kirkby, Mr. J. W. Salter, Dr. Henry Woodward, Dr. G. F. Matthew, Prof. Bailey, Mr. A. Smith Woodward, Mr. Robert Kidston, and Prof. David White, have all contributed by their writings. published or in manuscript, to the literature of this interesting controversy.

I shall not attempt to review the difference of opinion which may exist between what may be turmed the two schools of geology as regards the constitution of the Devonian system, especially as regards the uppermost members of that system,—*The Lonsdalean* School, whose characteristics of the Devonian age are based more especially upon the life-zones or palæontological evidence which the formations hold, and *the Murchisonian* School, which emphasizes more especially the stratigraphical succession, with little reference to palæontological evidence.

From a considerable study of the origin or genesis of the various geological formations in question, or of the cycles of constructive forms affecting them, the periods of erosion noticed, together with the life-zones which these formations contain, and characterize them, one has been able to arrive at a conclusion which, it is hoped, will be in accord with the views of the rest of the world, so that whatever interpretation is given to the Carboniferous system in one continent, the same should likewise hold good for another. The same with the Devonian system.

Just as Time was a constant factor during the evolution or history of the Carboniferous system of this world, and that the amount of time involved is a definite period, so also was Life a constant factor; and the several subdivisions of the Carboniferous system—the Eo-, Meso-, and Neo-Carboniferous, must be marked by corresponding series of Life-zones of the same system.

No difficulty has been experienced in separating the various geological formations in the Counties of Nova Scotia mentioned above, nor of understanding their taxonomic relations. The most excellent work of Mr. Hugh Fletcher, of the Geological Survey of Canada, who kindly furnished me with maps and plans of the region in question, shows clearly the true and natural order of sequence of the formations. The main question at issue, however, has been where to place the series of sediments hitherto known, and designated by Mr. Hugh Fletcher as the "Rocks of Union and Riversdale": in the Carboniferous or in the Devonian system. Mr. Fletcher would place them in the Devonian. I include them as formations in the Carboniferous system (and would also classify in the same system the red rocks of Mispec and the Lancaster fern-ledges of New Brunswick, which hold much the same flora and fauna). The various formations of the Carboniferous system do not form an unbroken succession of sedimentary strata in the disputed region either of Pictou, Colchester and adjacent counties. Great breaks and unconformities appear on every hand.

It may not be considered out of place here to look for a moment at some of the principles involved in such questions as arise in this problem. Portions of formations constituting cycles of sedimentation or of constructive forms, marking peculiar physical conditions of deposition, followed by periods of erosion, and subsequent depositions, occur at various horizons, and were it not for their entombed faunas it would be most difficult to state in which of the subdivisions of the Palæozoic column to place them. Where sedimentation as marked by cycles of constructive forms is not continuous, the basis or principle upon which the separation of the different members of the series depends, must obtain in the palæontological evidence collected in the various members whose succession, though not perfect, is, nevertheless, known as to its order.

Similarity in the types or organic forms found, assists one in uniting series of sediments as part and parcel of one system, just as dissimilarity enables one to separate series of sediments from

which they were derived. Comparisons must be instituted between the various life-zones occurring in the natural succession of strata, and wherever they are exposed they can easily be recognized however fragmentary or isolated they may be, provided they are fossiliferous, and that the evidence thus obtained can be compared with standard sections recognized the world over. The characteristic life-zones of the Carboniferous System, as they have been elaborated the world over, can be very easily prepared, and in order to be recognized as typical they must be in accord with the concensus of opinion with the rest of the world. They must not contain assemblages of organisms or types which are not in harmony with, but must be organically and chronologically related to, the types that are everywhere held to be of Carboniferous age. Fortunately for the geologist, although there are unconformities or breaks in the succession of strata there is abundant evidence of life of various orders and classes entombed in the various formations.

The Joggins Section.

One grand and continuous section of strata of the Carboniferous system to very near the summit thereof, in which are entombed myriads of organisms, plants and animals in regular succession also, is found along the Joggins shore, in the western portion of Cumberland County, Nova Scotia. This section was described in detail by Sir William Logan, and subsequently by Sir William Dawson and Dr. R. W. Ells. It extends from Minudie to McCarren's Cove, along the shore of the Cumberland Basin. This forms one standard section. No other such exists in Nova Scotia, and a systematic collection of the fossil organic remains entombed in its strata ought to be made for reference, in order to compare the succession of life-zones here with those of other portions of Nova Scotia and North America. In the United States, Mr. David White informs me that there have been noted not less than seven standard sections of the Carboniferous System, in distinct fields: Pennsylvania, Virginia, Ohio, Missouri and other States. These all have their peculiar charac-

ters, and may be described as local series. Whereas each particular basin of Carboniferous rocks or sediments may have its own particular conditions of sedimentation which led to peculiar local differences existing between the several basins which may be under examination and comparison, there can be no doubt at all about the series belonging to the Carboniferous System, when the results obtained in Great Britain, France, Germany, and the world over, have been consulted.

Such a recognized succession as the consensus of opinion in the world has established as marking the Carboniferous System, must be a term which includes within its scope the various members of the different local series under examination.

Unequal amounts of sedimentation at different horizons in a System and in different districts, have created difficulties, but formed an interesting feature in the study of the correlation of strata. It has been conceded that in the case of the 14,000 feet of strata which constitute the Joggins section in Nova Scotia, sedimentation must have been very rapid, and though deposited in a perfectly unbroken succession, such strata may have taken much less time actually to be laid down than a few hundred feet of shales and sandstone belonging to the same system in another section.

It follows from this, that local series of Carboniferous strata may be of very great thickness in one part of the continent, or comparatively thin in another part. It is possible for the whole system of the Carboniferous to be unusually extensive in its development of sediments, as has certainly been the case in Nova Scotia when compared with sediments of the same age in Pennsylvania. There is evidence of great rapidity in sedimentation. Evidence of rapidity in sedimentation is clearly seen in the strata, what I refer to the Eo-Carboniferous of Colchester and Pictou Counties in Nova Scotia, as represented by the Union and Riversdale formations. Ripple-marked surfaces and shallow water indications occur on all sides. Hundreds of feet of unbroken succession of strata, practically each stratum beautifully marked by ripples and wind action, as well as by the foot-

prints and trails of reptilian and other animals, such as are seen to occur at East and West Bay, near Partridge Island, Parrsboro, and point clearly to rapid deposition or accumulation of sediment along a fast-sinking floor.

The main reason for introducing this argument is to combat the view advanced in certain quarters, that by placing the Union and Riversdale formations into the Carboniferous system, it would make the latter too cumbersome and unwieldly a system, and take away from an older, underlying system—the Devonian, and rob it of parts of its sediments. The following occur to me to constitute the successive series or sediments which belong to the Carboniferous system in certain portions of Nova Scotia.

I.—The Eo-Carboniferous.

In this lower portion of the Carboniferous system, I would place the Union and Riversdale series of sediments, which are well and extensively developed in Pictou, Colchester and Cumberland Counties; at Union and Riversdale; along Harrington River; on the Moose River; at East and West Bay, near Parrsboro; Archibald's Brook; Oliver's Mills; McKay's, etc., on the East River of Pictou, and at numerous other localities.

The expressions "Rocks of Union and of Riversdale," I would describe as formations, calling one the Union formation, the other, the Riversdale formation. These are easily recognized over wide areas, geographically, and are characterised by a well-defined fauna and flora, at least as far as the Riversdale formation is concerned, the Union formation owing to its highly ferruginous character proving almost everywhere to be very destitute of fossil organic remains.

Fossils from the Riversdale Formation.

The two principal localities from which the fossils of this formation may best be obtained, occur in the Riversdale Station district, close to the boundary line between Colchester and Pictou Counties, and in the Harrington River district near the boundary between Colchester and Cumberland Counties.

Riversdale District.—Fossils from this locality were obtained along the Black River branch of the Salmon River, along the Calvary Brook, just east of Riversdale; also in the numerous cuttings along the line of the Intercolonial Railway between West River Station (Pictou County) and Riversdale Station (Colchester County).

In the rather fine grained dark gray or greenish gray arenaceous and black or dark carbonaceous shales of the cuttings along the I. C. R., plants, as well as animal remains, occur. Amongst the groups of organic remains examined and reported upon up to date are a series of plants sent to Mr. Robert Kidston of Stirling, Scotland. The entomostraca were submitted to Prof. T. Rupert Jones, F. R. S., and the crustacea (Podophthalmata) to Dr. Henry Woodward.

PLANTÆ.

1. Arterophyllites acicularis, Dawson,(=Calamocladns equisetiformis, Schl.)
2. Sphenopteris marginata, Dawson.
3. Neuropteris, sp.
4. Alethopteris, sp.; allied to Alethopteris valida, Boulay.
5. Cordaites principalis, Germar.
6. " Robbii, Dawson.
7. Cyclopteris (Nephropteris) varia, Dawson.
8. Calamites, sp. (?)
9. Cardiocarpum cornutum, Dawson.

CRUSTACEA, (Xiphosura).

Belinuridæ.

1. Belinurus grandævus, Henry Woodward and T. R. Jones.

CRUSTACEA, (Entomostraca).

Phyllopoda.

1. Leaia tricarinata, Meek and Worthen.
2. Leaia Leidyi, var. Bæntschiana, Beyrich and Geinitz.
3. Estheria Dawsoni, Jones.

LAMELLIBRANCHIATA.

1. Anthiacomya elongata, Dawson.
2. " obtusa, Dawson.

Insecta.

1. "A neuropteroid insect allied to Miamia Bronsoni"—determined by Prof. Charles Brongniart, of the Muséum d'histoire Naturelle, Paris, France.

Vermes.

1. Spirorbis Eriaia, Dawson, attached to leaves of Cordaites Robbii, Dawson.

Harrington River District.—The shales and sandstones, from which the fossils of the Riversdale formation were obtained, occur along the boundary of the counties of Colchester and Cumberland—the strike of the strata being generally across the direction of the stream. As pointed out by Mr. H. Fletcher, this locality proved to be particularly rich in fossils.

PLANTÆ.

1. Arterophyllites acicularis, Dawson.
2. Calamites, sp.
3. Sphenopteris dilatata, Dawson.
4. " Harttii, Dawson.
5. " splendens, Dawson.
6. " marginata, Dawson.
7. " sp.
8. Aneimites valida, Dawson.
9. Adiantites ? or Archæopteris, sp.
10. Neuropteris, sp.
11. Alethopteris discrepans, Dawson, (=Alethopteris decurrens, Artis, sp.)
12. Cyperites-like leaves.
13. Cardiocarpum cornutum, Dawson.
14. Psilophytum ? glabrum, Dawson.

Animalia.

BATRACHIA.

1. Hylopus Logani, Dawson.

2. Sauropus Dawsoni, (M. S.)—From rocks apparently of this age which occur at East Bay near West Bay and Partridge Island, two miles below Parrsboro.

LAMELLIBRANCHIATA.

1. Anthracomya elongata, Dawson.
2. " obtusa, Dawson.

CRUSTACEA.

1. Leaia tricarinata, Meek and Worthen.
2. Carbonia, sp.
3. Estheria Dawsoni, Jones.
4. Anthracopalæmon ? n. sp.

The Riversdale formation thus carries a flora and fauna, which cannot be taken as one appertaining to any other system than the Carboniferous, inasmuch as the types are all akin, and generally conceded to be closely related, even to types in the productive coal measures higher up in the system.

I have no hesitation to state that, in the Union and Riversdale formations, we have obtained in Nova Scotia a fauna and flora, which, while not as extensive nor as varied as that obtained in the productive coal measures of the same Province, are nevertheless remarkably similar in their biological characteristics, imbedded in a series of sediments, terrigenous in character, and for the most part estuarine, carrying Carbonaceous shales and sandstones, underclays and conglomerates, constituting just a series of strata as that, which, having begun in Eo-Carboniferous time, were interrupted by an encroachment of the Carboniferous Sea (Windsor formation) in which marine conditions prevailed, and limestones were deposited, holding abundance of marine shells and other fossil organic remains peculiar to salt-water conditions, and were followed by newer, or higher, or later strata, such as are met in the "Millstone grit" and "Coal measures" of the same region, of various writers, characterised also by terrigenous deposits, and enclosing a fauna and flora whose affinities are remarkably akin to the forms found in the Eo-Carboniferous

formations of Union and Riversdale, giving us the following natural, though interrupted general succession of strata, in descending order :—

Succession.	Conditions.	Fossils.
III. Coal Measures and Millstone grit,	Estuarine.	Land plants, land animals, shallow water conditions and forms.
II. Windsor formation.	Marine.	Marine shells, corals, sea-life.
I. Union and Riversdale formations.	Estuarine.	Land plants, land animals, shallow water conditions and forms.

As evidence of the similarity of forms peculiar to the Eo-Carboniferous of Colchester and Pictou Counties and the Coal measures of the same, let us take the different orders or groups of fossil organic remains affording Palæontological evidence as noted on page 181 of the "Summary Report of the Geological Survey Department for 1898 and 1899."

Evidence from Animal Life.

Insecta.—Neuropterous insects have been discovered in the shallow water deposits of Riversdale age, in a cutting on the Intercolonial Railway east of Riversdale and Campbell's Siding, about a mile and a half west of West River Station, and the *wing* obtained and sent to the Museum d'Histoire Naturelles, is referred to a Carboniferous genus by Prof. Brongniart, of Paris, France—a most eminent authority on the Fossil Insects of the Carboniferous.

Phyllopoda.—The numerous specimens of *Leaia* and *Estheria* from the Carbonaceous and other shales of the Riversdale formation of Colchester, Pictou, and Cumberland Counties, are very similar to the forms described from the Coal Measures of Pictou, County, and also from the Coal Measures of the United States. All the species of *Leaia* recorded in North America so far, are

referred to the Coal Measures. This genus, however, was abundant in early Carboniferous times, as may be gathered from those specimens obtained by me in the red, black and gray shales of the Union and Riversdale formations of Nova Scotia, which, though they underlie the Marine limestones of the Windsor formation, are nevertheless referred to the Eo-Carboniferous, a position which the enclosed fauna of Phyllopods warrants in assigning.

Crustacea.—Several specimens of a new genus, and new species of one of the Podophthalmata and Xiphosura, occur in the Harrington River and Riversdale collections in Colchester County. These Crustaceans are highly characteristic of the Carboniferous system in Europe and America, and their occurrence at this horizon, together with their generic characters, point to them as prototypes of higher forms found in the higher subsequent cycle of sedimentation in the series of sediments referred to in the Coal measures above. Of these, *Bèlinurus grandævus,* T. R. Jones and H. Woodward, has been recently described, and the authors describe it as a Carboniferous form, related to Carboniferous species in Great Britain.

Amphibia.—Of these animals there are both footprints and trails in the collection of the Geological Survey or National Museum at Ottawa, which are referable to the genera *Sauropus* and *Hylopus,* which were obtained from rocks of Union and Riversdale horizon, and some are of gigantic size. All other footprints referable to this genus in North America, have been described as Carboniferous and, consequently, the Parrsboro and Spencer's Island specimens are Carboniferous, rather than any other horizon.

In his "Geology, Chemical, Physical and Stratigraphical," Oxford, 1888, Professor Prestwich gives a table "Showing the character and distribution of the species of organic remains in the several main groups of the Palæozoic series in the British area." Under the head of Amphibians (including footprints) he notes the occurrence of these in the Carboniferous, but none in the Devonian.

Dr. S. A. Miller, in his "North American Geology and Palæontology," containing that useful Catalogue of North American Palæozoic Fossils, does not record a single Amphibian from rocks older than the Carboniferous, and the genera *Sauropus* and *Hylopus* occurring in the Riversdale formation of Nova Scotia, are identical with and similar to those found in the Carboniferons, or other regions of North America.

Prof. James D. Dana, in his "Manual of Geology," Sir Archibald Geikie in his "Text Book of Geology," also, all the leading nomenclators and writers on North American or European Geology and Palæontology, agree in placing the genera *Sauropus* and *Hylopus* to which I have referred the footprints from Parrsboro and Harrington River, of Cumberland and Colchester County, from the Riversdale formation, as Carboniferous.

Lamellibranchiata.—Of these the most conspicuous are the *Anthracomyæ* of Salter, which Sir William Dawson described under the name of Naiadites. These shells are abundant in the Coal Measures of the Joggins, Springhill, Pictou and Sydney Basins of Nova Scotia, also in the Pennsylvania, Virginia and other coal areas of the United States, not to speak of their occurrence in the Carboniferons of England and France, and many other countries of Europe. They occur in bands in the Riversdale formation at Riversdale, and in numerous outcrops along the banks of the Harringtoh River, on the dividing line between Colchester and Cumberland Counties, and the term "Naiadites Bands" or "Naiadites Shales," which are usually associated with Ostracoda of the genus Carbonia, and other allied genera of Carboniferous affinity, is applicable to these Eo-Carboniferous bands. All writers on Geology and Palæontology, concur in placing these shells in the Carboniferous. All the species recorded from the United States are referred to the Coal Measures, whilst those from the Union and Riversdale formations of Colchester and Cumberland Counties in Nova Scotia, are, by the writer, placed in the Eo-Carboniferous. It will thus be seen that the palæentological evidence adduced in the geological collections so far obtained from the Riversdale formation of Nova Scotia,

including Insects, Phyllopods, Crustaceans, Amphibians and Lamellibranchiata, are all types which are markedly akin to types well known to occur in the Carboniferous of other countries, and more than that, such are usually met with in the Coal Measures of the same.*

It has been one of my constant endeavours to obtain Devonian fossils from those areas of Nova Scotia ascribed to the Devonian in the Riversdale and Harrington River Sections; but I have found only Carboniferous types.

Evidence from Plant Life.

Besides the above, there is the evidence adduced from the flora collected in the strata which yielded the forms of animal life just cited above, and it can be truly said that it also has a decided Carboniferous facies. The genera *Asterophyllites, Sphenopteris, Alethopteris, Cardiopteris, Stigmaria, Calamites, Poacites, Cordaites* are all represented. From communications recently received from Mr. Robert Kidston, of Stirling, Scotland, the well-known author of the British Museum Catalogue of Carboniferous Plants, who has examined the forms sent him, we learn that he is satisfied that the flora is truly a Carboniferous one.

Quite independently, Prof. David White of the Smithsonian Institution and United States Geological Survey at Washington, arrived at the same conclusion when he kindly made a preliminary examination of the collections from Nova Scotia cited above, and then in our possession at Ottawa, and invariably referred the forms detected to the Carboniferous system.

From our own study of the numerous collections obtained in the so-called disputed areas in question, from the areas of the Riversdale formation, we cannot but come to the conclusion that instead of finding Devonian types of plants and animals, they proved in almost every case to be Carboniferous. Neither is it to be wondered at, that, on studying the affinities and relations of the fossil plants, etc., of Riversdale, McKay's Head, and Har-

* The term "Coal Measures" is an unfortunate one to designate a Geological formation, and should never be used to designate horizon. It is a purely lithological or economic term, and conveys no idea of the Geological position in the Time scale. Productive Coal Measures can occur at any horizon in the Carboniferous.

rington River, from strata now referred to the Riversdale formation, Sir William Dawson placed them in the Millstone Grit formation, so intimate are their relations to the plants of the Coal Measures; and from my own observations also to the faunas and floras which are now known to immediately underlie the Millstone Grit of certain portions of Nova Scotia.

The Riversdale formation must now, therefore, both on account of its position in the succession of sediments and especially from the life-zones it holds, be classed as an Eo-Carboniferous formation. This formation clearly underlies that series of marine limestones referable to the Windsor formation, as this has been described and mapped out fully by Sir Wm. Dawson, and more lately and with special care and accuracy by Mr. Hugh Fletcher.

II.—The Marine Sediments.

In the districts of Nova Scotia under examination, besides the Eo-Carboniferous formations of Union and Rivesdale, consisting of red shales and sandstones and conglomerates, more or less strongly cemented together, together with the series of dark grey coloured, and black or greenish and rusty shales as defined by Mr. Hugh Fletcher, forming a great thickness of sediments, constitute one of the cycles of sedimentation peculiar to the Carboniferous System, there occur certain other strata overlying these unconformably, viz.: the marine limestones and associated gypsum, marls, shales and sandstones.

These marine limestones, &c., hold abundance of fossil organic remains, as shown on the East Branch of the East River of Pictou at Springville; at Brookfield; and Miller's Lime Kiln near the D. A. R. Bridge, Windsor, N. S., where the series is highly fossiliferous and the forms are well preserved. The term, "Windsor Series," is quite applicable to these strata and deserves to be recognized as constituting a typical formation or phase of the Carboniferous system in this portion of Eastern Canada.

Just where to place this *Windsor formation* in the column of Palæozoic formations has not yet been definitely ascertained. Whether it is to be classed as one of the Eo-Carboniferous sediments, or whether it constitutes a factor or part of what may be termed, according to Prof. H. S. Williams's very appropriate classfication, Meso-Carboniferous, is the question occupying our mind at present. It is, nevertheless, to be remarked that the fauna it contains is one in which so far not one of the Uppermost Devonian fossils of the Gaspé and other regions of Eastern Canada have been detected.

The occurrence of this formation in certain basins of Nova Scotia marks a cessation of the conditions existing in the areas which these limestones cover, showing that the sea or Atlantic waters in Carboniferous times extended over the Eo-carboniferous deposits previously laid down, which had been subjected to subsidence and erosion previous to their being overlaid, whilst the vegetation and climate did not, probably, change very materially in the high land during this period of submergence and encroachment of the sea. A period of elevation evidently must have followed the deposition of the limestones, marls, &c., and sandstones and mudstones and shales were deposited, to be followed later again by sandstones with shales and coal seams peculiar to the "Coal Measures" and "Millstone Grit" formations.

Such deposits are essentially terrigenous as to their origin and the structure, as well as origin and mode of deposition of the Coal Measures need not be described. The flora and fauna they hold mark the estuarine conditions existing and prevailing at the time, also the luxuriant growth of plants on land with the contemporaneous animal life of the period both in the water and on the land also.

A brief summary of the succession of the sediments in the Carboniferous of Nova Scotia in Pictou, Colchester and Cumberland counties in part, such as the writer has observed it in numerous outcrops and localities, gives the following section in ascending order :—

1. *Riversdale and Union formations:* Consisting of red

sandstones and conglomerates, carbonaceous shales and mudstones, besides diorites and other basic intrusive rocks.

2. An unconformity.

3. Windsor limestones and Hopewell sandstones, constituting distinct formations which overlie the Union and Riversdale formations.

4. (An unconformity, according to Mr. Fletcher.) I have not yet been able to detect any unconformity at this juncture. There is no unconformity between the Millstone grit and the underlying shales, calcareous and other conglomerates and sandstones of Cumberland Basin.

5. Millstone grit of Skinner McDonald's Brook.

6. In certain portions of Pictou County, N. S., an unconformity occurs, *e. g.*, at Blackwood Brook, opposite New Glasgow, where the upturned edges of the "Millstone Grit" (Logan) are overlaid by the New Glasgow conglomerate of Fraser's Mountain, &c., whereas in other portions the Millstone grit is directly superimposed by the Coal Measures, *e. g.*, at Westville and the Joggins.

This peculiar geological succession in these two areas give us two series of sediments in the succession of formations which in part only are synchronous, hold similar organic remains, but exhibit great variety in sedimentation.

A. *Joggins and Westville Areas.*	B. *New Glasgow Region.*
V. Millstone grit.	V. Millstone grit.
VI. Coal Measures.*	VI. Unconformity (of Blackwood Brook).
	VII. New Glasgow conglomerate.
	VIII. Spirorbis limestone.
	IX. Smelt Brook shales and sandstones.
	X. Pictou sandstones.
	XI. Cape John formation, red sandstones and conglomerate.

* The Coal Measures of Pictou County at Stellarton and Westville consisting of bitumous shales, clays and sandstones, are not anywhere seen to be overlaid by any of the formations in series B.

We would thus have the following tentative TABLE OF FORMATIONS in the Carboniferous of part of Nova Scotia:—

FORMATIONS.		Northern Areas.	Southern Areas.	Order.
NEO-CARBONIFEROUS	Cape John......	Cape John Sandstones..	....	XII.
	Pictou	Pictou Freestones........	....	XI.
	Smelt Brook....	Smelt Brook shales	....	X.
	Small's Brook..	Spirorbis limestones......	....	IX.
	New Glasgow ..	N.Glasgow conglomerates	....	VIII.
			Coal Measures .	VII.
		Unconformity.		
MESO-CARBONIFEROUS	Stellarton..... } Westville .... }	Millstone grit	Millstone grit...	VI.
		....	Unconformity (?)	V.
	Hopewell	....	Hopewell and Windsor....	IV.
	Windsor........	....		III.
		Unconformity.	....	II.
EO-CARBONIFEROUS	Union	....	Union .... Riversdale....	I.
	Riversdale	....		

NOTE.—It is not at all improbable that the Smelt Brook formation (IX.) overlying the New Glasgow (conglomerate) formation is equivalent to the Stellarton (VI.) or "Coal Measures" formation, which would indicate clearly the existence, as in other portions of the palæozoic in Eastern America, of two distinct series of formations which are nevertheless synchronous. The writer hopes shortly to describe each of the formations indicated in the above tentative Table of Formations for a portion of Nova Scotia, together with the relations of the latter to other palæozoic sediments in the same and adjoining Province of New Brunswick.

V.—THE NATURAL HISTORY OF MONEY, BY PROF. J. DAVIDSON, PHIL. D., *Fredericton, N. B.*

(Read May 14th, 1900).

It is hardly possible to determine whether there ever was a time in the history of the race when each individual was self-sufficient, and, like the Homeric Cyclops, paid no regard to others. Some of the Australian tribes are so low in the scale of civilization that even barter is unknown amongst them, but whether these represent the universal primitive type cannot be determined one way or the other. It is evident, however, wherever we find the first germs of social life, we find, at the same time, a kind of rude division of labor which necessitates, and renders possible, the beginnings of trade. Trade in its origin is simply barter, the direct exchange of one article for another. But barter, however simple in appearance, is more complicated than modern exchange. It must often have happened in the early history of trade that two parties failed to make a trade for the simple reason that, while both were anxious to give what they had, in exchange for what they wanted, neither of them needed or desired what the other had to offer. This lack of coincidence has frequently placed travellers in very great straits. If the native who holds the store of food does not find in articles which the explorer displays to catch the aboriginal fancy, something which attracts him, he passes on, and the traveller and his party have to go hungry. Sir R. Burton warns the would-be explorer against assuming that any sort of trinkets will suffice for the purchase of supplies and the hiring of labor. The African native has his own standard of taste, and no matter how gaudy and how gimcrack the stock of Brummagem goods displayed may be, the native will take such things only as agree with his standard of taste. Nothing will induce the primitive savage to take what he does not immediately require in exchange for the food the traveller desires,

unless the articles offered in exchange conform to his standard of taste.

The inconveniences of this primitive state of barter are so evident that no race or tribe which has made the first step away from barbarism, can for long remain without some sort of medium of exchange. There is need of some commodity which will be readily received by every one, although at the moment he may not wish to consume it, in the full assurance that he can easily, in his turn, exchange it for the article he does desire. Such an interposed commodity will greatly facilitate exchanges, and to all intents and purposes may be regarded as money. What this interposed commodity is depends almost entirely on circumstances. At first, almost any commodity which is esteemed by everybody in the community will serve the purpose. There is no more foundation for the idea that there was a sort of social contract regarding some one article to be used as a medium of exchange than there is for the other historical fiction that law and language are due to a primitive contract or convention. No one article has been adopted as if by natural right. The original medium of exchange was simply a marketable article with a recognized value. Metallic money has reached its present supremacy because in the struggle for existence it has demonstrated its superiority. There is no natural desire for the precious metals ; and even for gold there does not seem to be any natural and inherent desire apart from its utility. The *sacra fames auri* is a fiction of the poet and a description of the civilized mind ; and the first discover of a gold nugget possibly viewed it as a sort of substitute for a bead or a shell for a necklace. Even to this day, there are peoples who do not esteem gold, and will give nothing for it. The various British and Egyptian Soudan expeditions were compelled to take along with them bulky Maria Theresa dollars, because the Arab would not take gold in exchange. The taste of the Arab is for silver ornaments. He is no fanatical silver man desirous of seeing silver remonetised. Gold he could not, or at least was not accustomed to, use as ornaments for his person, his horse, or his

weapons. Hence, gold had little utility for him, and the transport service was burdened with large quantities of bulky Austrian silver dollars. There are certain qualities which civilized communities require in the medium of exchange; but in early commerce these were not always demanded, perhaps often not even thought of. Each community has selected the commodity which best suits its conditions, and in the course of progress each has adopted and in time abandoned many kinds of money. But whatever the nature of the medium of exchange adopted, it served as money; and it is justly entitled to be called money, even although not metallic, or not coined; for, after all, as Prof. Walker says, "Money is that money does." For the needs of modern trade, primitive money materials are entirely unsuited; but they serve their own purpose, and as in the eyes of an early missionary to the Mexicans who, contemplating the bags of cocoanuts used by the Aztecs, exclaimed, "Blessed money! which exempts its possessors from avarice since it can not be long hoarded or hidden under ground," primitive money may have peculiar advantages of its own!

When in any district or community any particular commodity comes into general use, and is readily available, it generally comes in time to be unit of value and the medium of exchange. Its nature will, of course, depend on the climate and geographical position of the district; and may be changed when the community advances to another stage of culture. The natural medium of exchange may be altered, even although the community has made no such advance. When a primitive community comes into commercial contact with a more advanced race, an entirely new medium of exchange may be adopted. Thus, gin and gunpowder are, according to Bishop Tugwell, of Uganda, to all intents and purposes, the only currency in certain parts of Africa. The foreign trader may create a new value by his demand for produce which hitherto has been little esteemed. In the Caroline Islands stone money in the form of quartz wheels, varying from six inches to twelve in diameter, was formerly the money the natives used; but since the advent of

the white trader bags of copra or dried cocoanut kernel have come into general use.* The usual effect of such a contact of races has been the substitution of a corresponding manufactured article for the original commodity used by the natives. Thus, among the Pacific Coast Indians, blankets have become the medium of exchange in place of furs. Since all exchange is mutual, the civilized trader must abandon his natural medium of exchange and adopt the medium of exchange prescribed by the character of the trade. Thus, in the New England colonies, wampum, a form of shell money, and in French Canada, beaver skins, were used naturally in the trade with the Indians at all times; and on occasion, owing to the scarcity in the colonies of small change, these articles were used as money between Europeans. Indeed, in many communities where money, as we know it, is, for one reason or other, scarce, commodities may come into use as money, not because the people know no better, but because they have no better. Thus, on the north-east coast of Newfoundland at this day, cod alone is currency.†

The natural currency of a community is that commodity in which its wealth mainly consists. In the hunting stage of society property consists in weapons of war and the chase, in a few simple, natural ornaments made of shells or teeth, and in the skins of animals, which serve for clothing, and for the covering of the hut or wigwam. But as man advances in civilization, he succeeds in taming animals, whose flesh and milk form his foods, whose skins or wool form his clothing. This is the pastoral stage in which a man's wealth is reckoned by his herds. In the more settled agricultural stage, property consists not only of slaves and domesticated animals, but of dwellings and grain, and above all, of stocks of the precious and other metals, though indeed, in early history, all metals are precious. These later forms of wealth man has come to value according to his earlier standards of wealth; and there is every reason to believe that the original standards of value of metallic coins are based on mere primitive ox and cow units. When man has come into

*F. W. Christian. Geographical Journal, Feb., 1899.

†Lant: Cruising on the French shore Westminster Review, March, 1899.

the possession of the metals, and has acquired the power of working them, a long course of monetary development is possible for him. He finds out by experience which metal suits his purpose best; and that purpose may change as the centuries pass. Our present currencies are the result of the law of the survival of the fittest. The primitive condition was general use; and that always remains the first condition of the use of an article as currency. But along with that, there are other conditions which are stated in every monetary text-book. All the metals have been used in turn. Iron was used in Sparta, and is used to-day in the Dark Continent. Lead and tin, and platinum, gold, and silver, and copper, have all been used. But experience has shown that gold and silver pre-eminently, and copper, or some alloy of it, in a less degree, are best suited for currency purposes.

This has been the general course of development; but though it is sometimes hard, amid all the talk about progress to realize that the stationary state of society is the usual phenomenon, yet it is true that most peoples have not become civilized, and since many remain in the most primitive stages of society, we still have many actual instances of primitive currency in present day use. Progress seems alike impossible in the frozen north and in the torrid south; and in these regions the conditions of life are almost unchanged, and there we may see the kinds of money our forefathers of untold generations ago employed.

The rigour of the northern winters prevents the rearing of domestic animals, or the systematic cultivation of the soil, and there the primitive hunting stage still exists. The wealth of these Arctic communities consists in skins, and in some cases of dried fish, which they exchange with the trader from the south for their few luxuries or use for their own clothing and sustenance. Under these conditions skins, or their modern equivalents, form the natural medium of exchange. A writer in a popular magazine gives a graphic description of the skin money used in the Hudson Bay Territories:

"In old times, when an Indian wanted a rifle, the rifle was stood on end, and the Indian laid furs flat on the ground till

they were heaped to the top of the gun barrel; then the Indian took the rifle, worth possibly $50, and the Hudson Bay Company took the furs, worth from $100 to $1000, the large variation being due to the absense of discrimination on the part of the Indian . . . .

"At the Hudson's Bay Company posts, on the Mackenzie River, actual money is unknown; all trade being conducted by means of a curious imaginary currency, the unit of value of which is 'one skin.' What sort of skin? No one knows; in fact it is no sort of skin in particular. It is merely an imaginary skin, about equivalent in value to half a dollar. The hide of a beaver is worth ten skins; a musk ox hide is worth thirty skins; a fine silver fox hide is worth 300 skins. These are the big bills of this unique currency.

"Small change is made by musk rat hides, worth one-tenth of a skin; by mink hides worth two skins, and by lynx hides worth four skins. A wolverine hide is worth sixteen skins. There is a fluctuation in the value of this currency just as there is a fluctuation in the value of silver, consequent upon the increase or decrease in its production."*

But skin currency is not so unique as this writer imagines it to be. We have no modern instance so complete, but we have many traces of the same practice. In Northern Asia the skin of the Siberian squirrel was and is the monetary unit; and etymology shows that many of the northern nations were in the same position. "In the Esthonian language the word rûtra generally signifies money, but its equivalent in the kindred Lappish tongue has not yet altogether lost the original meaning of skin or fur."† And the name of a Russian small coin, the ¼ kopeck, is said to mean half a hare skin, showing that the Muscovites had originally a skin currency—a fact which is also established‡ by the circulation of leather money in Russia as late as Peter the Great. Even in regions where there were possibilities of development, the earliest money was of this

*Lee Merrithew: "Cosmopolitan," Nov., 1899.

†Jevons: Money and the Mechanism of Exchange, p. 20.

‡Ridgeway: Origin of Currency and Weight Standards, p. 13.

character. "Skin for skin, yea, all that a man hath will he give for his life," is a text we generally understand in some obtuse way to mean a reference to a man's own skin. What it really points to is that, even in the pastoral stage of society which the book of Job describes, skins were the standard of value; and classical writers record the traditions that the earliest currency used in Rome, Sparta, and Carthage, was formed of leather. Sir John Mandeville, or his unacknowledged authority, tells us that in China, when he visited it, leather money was in circulation.

We find what seems a still more modern instance in the fact that Saint Louis, the great king of France, finding a great scarcity of silver coin wherewith to pay his soldiers, caused pieces of silver wire to be fixed on leather and so circulated. But this was rather a device for protecting the silver than an actual leather money. The silver gave the value, and the leather served only as a case to preserve the small piece of silver (9 or 18 grs.) from being lost.

In some communities, particularly those brought into closer contact with the traders of advanced race, the blanket of the trader has supplanted the original skin currency. This has taken place in some parts of the Hudson Bay Company's territory and eleewhere. Along the British Columbia coast also the Indians use blankets as the unit of exchange. The blankets are distinguished by prints or marks on the edge woven into the texture, the best being four-point, the smallest and poorest one point. The unit of value in trade is a single two-and-a-half point blanket, worth about a dollar and a half. All commodities are exchanged according to this standard; even the four-point blanket is said to be worth so many blankets.*

In the case of these Indians the development may have been due to a growing scarcity of fur bearing animals, and perhaps from the same reason, and also from natural development, we find in Scandinavia, in Iceland, and in the Orkney Islands,

*Dawson: Report on the Queen Charlotte Islands. Geol. Survey Report of Canada, 1880.

that cloth was the standard. Wadmail, or coarse woollen cloth formed the basis of an elaborate system of currency in Norway.*

In Iceland this cloth currency gave place with the development of trade to a currency of stockfish. The foreign traders did not desire the northern coarse cloth; but there was a steady market in Southern Europe for fish. There is extant a proclamation for the regulation of trade between England and Iceland in which an elaborate scale of prices for articles of all kinds is drawn up in terms of dried codfish.† And in Newfoundlond cod was for a long time, and still is in many parts, the only coin.

In general, one may say that whenever there arises a scarcity of metallic money in a community which produces one chief article for trade, that article will serve as money. Thus cod was used in Newfoundland, tobacco in Virginia, wheat and maple sugar in Nova Scotia,‡ tenpenny nails, as Adam Smith tells us, in Kirkaldy, olive oil in the Levant, tea in Central Asia, block salt in Abyssinia, and in various parts of Asia and Africa.

The history of the currency experiments of the European colonies in North America is instructive. These communities suffered from a chronic want of coin, one of the results of an ill-considered colonial policy. Tobacco was a form of currency in Virginia sanctioned, not only by custom, but by actual legislation. In 1619, the first General Assembly of the colony established a ratio between tobacco and silver; and almost every succeeding Assembly dealt with the same question. In 1642, tobacco became the sole legal tender; and it was not till 1656 that silver could again be used if required. But tobacco remained the actual medium of exchange, and in 1730 paper money, like our modern grain receipts and pig iron warrants, was issued against tobacco. These, along with the commodity, formed the main money in Virginia down to the beginning of the present century, and were preferred, because more stable in value, to the continental currency. In the New England colonies a very great variety of articles of trade was made legal tender.

---

*Morris and Bax: Socialism, its Growth and Outcome, p. 249 *n*.

†Ridgeway: op. cit., pp. 18, 19.

‡Patterson: Memoir of the Rev. James MacGregor, D. D., p. 82.

Beaver skins formed the greater part of the circulating medium, and in 1631 it was enacted that grain could be paid unless beaver or money (that is metallic money) were called for by the contract. This law remained in force for half a century; and other agricultural commodities were added to the list as occasion seemed to demand. Corn, wheat, barley, and peas, at fixed prices per bushel, were sanctioned by law as currency, and taxes could be paid in them at the discretion of the taxpayer.*

A similar colonial policy produced similar results in French Canada. The scarcity of metallic money was even greater than in the English colonies; and at all times commodity substitutes for metallic coinage were in use. The scarcity was so great that in addition to the beaver skin, which was practically the unit of value, wheat was declared a legal tender in 1669 at four livres the mint, while in 1673 the council further ordered that bear skins could be tendered in payment at their current value.†

But to return to the monetary practice of primitive communities. In the torrid zone clothing is a burden, and nature supplies plenteous store of the food suited to the climate. The chief objects of desire are ornaments. The instinct for personal adornment is one of the most powerful instincts of the race. Shells were the earliest and simplest articles so employed; and we find shell money used in all parts of the world. In the torrid zone they still form the principal medium of exchange. The cowries of the countries round the Indian Ocean have many of the qualities which we require in the money material. They are durable, portable, and are universally esteemed. In India and Siam, in West Africa, as well as in East Africa, and indeed at one time or another in every country in the world on whose shores they are found, cowries serve as the small change of commerce. They are to-day collected in vast quantities in the Maldive and Laccadive islands to be exported to serve as money elsewhere. The value fluctuates enormously, depending on their abundance or scarcity. In Africa traders estimate a

*White: Money and Banking, Chap. 1.
†Kingsford: History of Canada, Vol. 1, p. 156.

thousand shells at a shilling, while in India 5000 represent a rupee. The area over which they circulate is very large; and we have evidence that they were at one time used in countries which have long since abandoned them. The familiar Chinese cash, which are estimated by the string, is at least part proof that shell money, which is usually strung for convenience sake, was once the currency of the Celestial Empire, although the cash itself is a survivor, not of this shell money, but of an original knife money of which we shall hear later. The money of the Solomon Islands consists of neatly worked pieces of shell about the size of a shirt button. These are strung on strings about four yards long, and are distinguished under the names of white and red money. In the Caroline Islands shell money circulates, not as shells, but as real money, without immediate reference to adornment. The shells are chipped all round till they form disks quarter of an inch in diameter, and then are smoothed down with sand and pumice. The porcelain money of China, and perhaps the clay tablets of Assyria and the seals of Egypt, may be perhaps regarded as more developed forms of the same kind of money. In other places shells of other sorts were used. In early China perhaps, also, among the early Greeks, tortoise shell was used, and in China to this day the phrase tortoise shell is still used to indicate money.*

The wampum of America is another instance of shell currency. It consisted of black and white shells polished and fashioned into beads, and then strung in necklaces, etc. Black ones were twice as valuable as white. Wampum was so well established as currency among the Indians that it was made legal tender among the settlers, not that white men valued it as ornament, but because it was in constant demand by the natives and also because there was a scarcity of small coin. The unit of wampum money was the fathom consisting of three hundred and sixty white beads, and was worth about sixty pence. At first wampum was legal tender only to the extent of 12 pence, or the limit of the legal tender of bronze coin to-day. But in

*Ridgeway: op. cit., p. 21.

1641, owing to a greater scarcity of coin, wampum was made legal tender up to £10, though in 1643 the limit was reduced to £2. The decline of the beaver trade drove it out of circulation. When it could no longer be exchanged in large amounts for beaver skins, an article of international trade, the basis of its value was gone, although its use was continued in the frontier districts well down into the eighteenth century.*

Shell money is still used by North American Indians. The tribes of California, according to Mr. Powers, make use for money not only of the red scalps of woodpeckers, but also "of the dentalium shell, of which they grind off the top and string it on strings; the shortest pieces are worth twenty-five cents, the longest about two dollars, the value rising rapidly with the length. The strings are usually about as long as a man's arm." When these Indians became familiar with the silver coinage of the United States, the use to which they put the dimes and quarters shows how the new money, as well as the old, derived its value as a medium of exchange, because it was prized as an adornment of the person. "Some of the young bloods array their Dulcineas for the dance with lavish adornments, hanging on their dress 30, 40, or 50 dollars worth of dimes, quarter dollars, and half dollars, arranged in strings."† The same aboriginal instinct appears sometimes among semi-civilized aldermen. The Bowery saloon, which was paved with silver dollars, used to be, and perhaps still is, one of the sights of New York; and it would not have been inappropriate had Silver Dollar Smith, the owner, been a member of Tammany, which in the day of its political power, still tricks its members out in paint and feathers on gala days and sends them down Third Avenue under their Sachems, brandishing tobacco store tomahawks.

Other articles which have been desired for purposes of ornament have also been used as money. The Californian Indians use not only shells, but the red scalps of woodpeckers for their

*White: Money and Banking, Chap. 1.

†Quoted Ridgeway, op. cit., p. 15. Conversely solid brass buttons with the eye hammered flat were extensively used half a century ago in St. John, New Brunswick, for small change.

greater units of value. In Fiji, whales' teeth were used instead of shells, and white teeth were exchanged for red teeth somewhat in the ratio of shillings to sovereigns.* In Africa ivory tusks, and in the Solomon Islands dog teeth, which are worn in necklaces, express the higher values, while shells are used for the smaller. The currency of the Solomon Islands includes many different articles, and the value of each relatively to the others is carefully determined. The currency table, as set forth by Mr. Cook,† is:

10 cocoanuts	=	1 string of white money.
10 strings of white money	=	1 string of red money, or
	=	1 dog tooth.
10 strings of red money	=	1 string dolphins' teeth.
10 strings of dolphins' teeth	=	1 fine woman.
1 mable ring (for ornament)	=	1 good hog or 1 useful young man.

When man becomes a worker in metals, the primitive shell ornaments are replaced by gold and copper, and silver; and much of the money used in Africa to-day is of this character.

But man is a creature of customs, and the forms of his necklaces did not change to utilize the peculiar characteristics of the new materials. Nuggets of native gold may have been here and there threaded on a string; but there is little doubt that man's first attempt in metal working consisted in imitating the old shell ornaments, and in imitating those shell ornaments which had come to be used as money. In Siam there are silver coins in the shape of shells; and in China we have a copper coin known as a Dragon's eye, which was fashioned in the shape of a cowry. But long before the precious metals were coined, they were in circulation by weight, as they still are in the East. The commonest form in which the metals circulated was in the

*Jevons: Money, p. 25.

†For these details regarding the Solomon Islands, I am indebted to a note in an issue of the "Popular Science Monthly," which I cannot find again. In the same note it is said that rope ends, ornamented with red feathers, to be worn about the waist, are also used as money.

shape of ornaments; and some writers have spoken familiarly of ring money as if it were really stamped and coined money such as we use to-day. In reality, the so-called ring money was an article of barter, circulating by weight. The ancient ring money of Egypt, and of the early Celts and Teutons, is represented in Africa to-day by the coin currency of Calabar, and the rod currency of the Congo region, these being simply brass or copper wire, soft enough to be bent into the rings and bracelets, and other ornaments in which the African black takes delight.

When man advances to the pastoral stage, which he has done, and apparently can do, only in the temperate climes in which cattle can live, we find him estimating his wealth in cattle; and naturally the medium of exchange adopted by such societies is that which all desire, and all in a measure possess. Most of the civilized nations have long since left their cattle currencies centuries behind; but still in their language and archæological remains, in their literatures and their religious customs, there survive traces of the days when cattle formed their standard of value and their medium of exchange. "It is very possible that kine were first exclusively valued for their flesh and milk; but it is clear that in very early times a distinct and special importance belonged to them as the instrument or medium of exchange."*

The Latin term "*pecunia*" is derived from "*pecus*," a herd; the English "*fee*" is from the Anglo-Saxon "*feoh*," which survives in the cognate German from *Vieh* cattle; and rupee is said to be derived from the Sanskrit *rupa*, which also means cattle; and in the Book of Job the word *Késitch* (= a lamb) is employed to signify a piece of money.†

The veneration in which the cow is held in modern India by a people to whom the eating of beef is an abomination, is held by some to point back to the ages when the ancestors of these people in some more northern region had a great respect for

*Maine: The Early History of Institutions, p. 149.
†Wilkinson; The Ancient Egyptians, Vol. II., p. 151.

cattle as forming the principal item in their wealth. And although every shepherd was an abomination to the Egyptians (Genesis, c. 46, v. 34), as Joseph instructed his brethren, yet the Egyptians worshipped their great divinity Apis under the form of a bull, and worshipped also a sacred ram; customs which probably show that at some time or other their ancestors, whether in the northern Soudan or in Asia, and still in the pastoral stage, had regarded with proper veneration the cattle and the sheep which constituted their wealth.

The earliest literatures both of Aryans and of Semites show that cattle were wealth, and the measure of wealth and the medium of exchange. The wealth of the Patriarchs was measured by their flocks and herds, and we need only refer, in the almost equally familiar stories in Homer, to the one-sided exchange between Glaucon and Diomede "of golden arms for brazen, those worth one hundred oxen for those worth nine." When history opens, most of the nations which afterwards played leading parts were still in the pastoral stage. Egypt had already passed beyond it, and the Greeks were making the transition to the agricultural and settled conditions of life. And as each nation first demands our notice whether in the Mediterranean region, in northern Europe, or in Central Asia, it is almost always the same picture that is presented of a pastoral people whose wealth consists in flocks and herds. And not only have we *a priori* reason to suppose that the chief item of their wealth formed their rudimentary medium of exchange; but we know from literature and from archæology that the ox was their unit of value. We have scales of value preserved to us in the Sacred Books of the East; and of these scales we have what might be almost exact transcripts among the semi-civilized tribes of the Caucasus and Central Asia, and of Northern and Southern Africa at the present day. The earliest coins of Greece which have been discovered are stamped with the head of an ox; and the legal code of Draco retains with true legal conservatism the otherwise obsolete practice of expressing values in terms of oxen. Indeed there is more than probability, there

is proof as strong as the nature of the subject permits, that our present system of metallic coins are translations of the earlier cattle currency. The Greek talent of gold and the ox were undoubtedly equivalent; and the ox is of course the older standard of the two; and the small change of this commodity currency was likewise translated into corresponding silver and copper coins. We find the same equating, the presence of which we partly detect and partly infer in the Greek world, going on to-day among peoples which are just passing from the pastoral to the settled mode of life.

When this change takes place man generally has some rudimentary knowledge of metallurgy; and the agricultural products have not often formed a unit of value. We have local instances and temporary instances; but these are by no means confined to the beginnings of the agricultural stage. They appear in colonial history almost as frequently as in semi-barbarous societies; and are generally due, then and now, to a scarcity of precious metals. Wheat has some advantages as a standard of value over the precious metals, as those colleges at Oxford and Cambridge know to their advantage who were restricted in the reign of Elizabeth to corn rents; but as a medium of exchange agricultural produce has such obvious disadvantages that no people which was able to use the precious metals has ever systematically used grain and other produce of the earth.

The metals are so much better suited than any other commodities to serve as the medium of exchange that it was inevitable that they should rapidly supplant all other forms of currency, so soon as gold and silver and the others had come to possess the fundamental requisite in a medium of exchange, viz., that it should be an article in general use and demand. But the metals came but slowly to possess this fundamental requisite; and we are certainly not justified in assuming that metallic currency superseded all others as soon as man had discovered the means of mining and working the metals. On the contrary, it is certain that the older currencies remained in circulation long

after man had acquired the necessary metallurgical knowledge In the Homeric poems we have evidence of the concurrent use of definite weights of gold and silver, and iron, with the older ox unit.

The metals acquire value as all other articles acquire value, because they are suited to satisfy certain human needs. After the metals have been adopted as money, they acquire a distinct and special importance because of their utility as the medium of exchange ; but first of all they must acquire the direct value that arises from direct utility. The metals are valued by man chiefly as ornaments, or as the material out of which the implements of industry or the weapons of war may be fashioned. The precious metals are valued for their utility as ornaments only. Neither gold nor silver had been put to serious use either in war or in industry. They obtained their value because of their attractiveness as ornaments for adorning the person, and in all probability the earliest form in which gold circulated was in strings of nuggets or beads resembling the older shell necklaces. Ancient geographers tell us that in Arabia native nuggets were used as ornaments. "Having perforated these they pass a thread of flax through them in alternation with transparent stones and make themselves chains, and put them round their necks and wrists."* But with increasing knowledge of how to work the metals, gold dust, as well as "fireless gold," as these Arabian natives called it, was fashioned into ornaments, and at first, no doubt, after the older models. Primitive coins are in existence, and in some cases still in circulation, in which the evolution from the ring and shell can be traced.

As man's chief employment in the early stages of society was war and the chase, weapons of war were greatly prized and jealously guarded. Consequently we find many traces of the employment of the implements of war as a medium of exchange. Even in the stone age we know that this was the case. Tough green stone slabs, valuable for making hatchets, form the unit of value among the lowest Australian natives who have hardly yet

*Strabo and Diodorus Siculus, quoted Ridgeway, op. cit., pp. 75-77.

advanced far enough to carry on trade by means of barter.* Weapons formed part of the currency of Homeric times and among the ancient Norsemen. By the laws of Hakon the Good penalties for breaches of the law could be paid among other things in weapons.† Gunpowder competes with gin in the battle of the African standards introduced by European traders; and, not long since, an English newspaper, in commenting on a petition of a philanthropic committee that some other form of currency than that of gin should be adopted in the Delta of the Niger, suggested more than half seriously that Lord Salisbury should use his influence with the concert of Europe "to make the Liverpool powder keg the only legal tender in the gin latitudes." Among all the aboriginal tribes which have been brought into contact with European traders, the musket quietly takes its place in the native standard of value. But in Borneo they have gone a step further. A brass cannon, or as it is called by the natives, a brass gun, is the standard of value, and in all parts of the island one may still hear prices reckoned in brass guns. Any one who has transactions of such importance, for the brass guns will correspond to our larger notes, will instantly translate the sum into dollars at the present day; but there was a time when ten or twenty pounders did actually pass from hand to hand.‡

In more recent times, and if not among ourselves, at least among the ancestors of many of us, bullets have circulated as small change. Leaden bullets were legal tender in the New England; and the reason was no doubt partly the atmosphere of warfare and danger in which the early colonists lived. But there was another reason. The want of small coin in the reign of Queen Elizabeth had induced tradesmen and others to issue token money; and in consequence there was great distress often among the poorer classes for the issuer not infrequently refused

*Tyler: Anthropology, p. 281.

†Ridgeway: op. cit., p. 35.

‡This fact is on the authority of an undated second-hand clipping from the "London Standard.

to honor these tokens. Accordingly, in the reign of James I., the striking of copper farthings was made a monopoly, and in the spirit of the times given to a court favorite, Lord John Harrington, who took unreasonable advantage of his opportunities. The circulation was encouraged in various ways with disastrous results to the commerce of the country. But not content with the fraudulent profits made at the expense of the commerce of the country, he caused large parcels to be shipped to the colonies. The Pilgrim Fathers, however, would have none of them; and it stands in the records of Massachusetts on "March 4th, 1634, at the General Court at New Town, brass (or copper) fathings were forbidden, and bullets were made to pass for farthings."

But the useful metals could also be put to the more fruitful use of serving as implements of industry, where their superiority over stone and wood is no less obvious than when they are fashioned into weapons of war. In Africa, which, owing to the absence of native copper, never had a bronze age, but passed at once into the iron age, we find still in full force the systems of currency which have either completely disappeared, or have left but indistinct traces elsewhere. There we find hoe money and axe money in practically their original forms. Iron in its natural state was a means of exchange in the Homeric age, and the iron money of Sparta was probably traditional in origin, like the Hindu reverence for the cow. But in Africa to-day iron is an almost universal medium of exchange. On the west coast the bar is the unit; and all things are reckoned in "bars" pretty much as they are reckoned in blankets among the Pacific Coast Indians. Originally the bar was what its name denotes, a bar of iron of fixed dimensions, one of the chief articles of trade between the natives and the early European traders. Now it has a conventional value, which, in Sierra Leone, is two shillings and threepence. In Central Africa, among the Madis, according to Dr. Felkin, "the nearest approach to money is seen in the flat round pieces of iron which are of different sizes . . . . They are much employed in exchange. This is the form in

which they are kept and used as money, but they are intended to be divided into two, heated and made into hoes. . . . . . Ready made hoes are not often used in barter. Iron, as above mentioned, is preferred, and is taken to the blacksmith to be fashioned according to the owner's requirements."* But in Darfur the actual hoe serves as currency. "It is simply a plate of iron fitted with a socket. A handle is fitted into this socket and one has an implement suited for chopping the weeds in the corn fields. Purchases of small value are made with the hoe from one to twenty,"† which may be said to be its legal tender limit. Larger purchases are made by means of cotton cloth and oxen. Among the wild tribes of Annam, in Asia, also, the hoe serves as currency, and in ancient times many nations seem to have used it. We know that the Chinese had originally a barter currency of real hoes and real knives, articles in great demand among them. These in time became conventionalised in form, and were reduced in size to serve as real money. The Chinese cash is the survival of the original knife money, while the hoe, in a certain form, still circulates in Thibet, as it did in China hundreds of years ago. Within recent years the Thibetans have adopted the Indian rupee; but have not preserved its integral form. They cut it up for purposes of small change into little pieces which represent the conventionalized form of their own original hoe currency.

The hoe served as a general article of barter because of its indispensability in agriculture; but among fishermen the fish-hook was a more useful and desirable implement. Among the fishermen of the Persian Gulf, and round the coast to Ceylon and the Maldive Islands, there was originally a fish-hook currency; and when true money was adopted the old form was retained. Down till the beginning of the present century *larins*, a bent piece of silver wire, the conventionalized form of the fish-hook, were in circulation; and it is possible that, had the natural process of evolution gone on without interference from

*Quoted Ridgeway, op. cit., p. 43.
†Ridgeway, op. cit., p. 45.

the outside, in course of time the piece of double wire would have become a bullet-shaped piece of metal, just as the bullet coins of Siam struck in European fashion represent the last stage of the original ring currency of that country.*

At one time axes served as money in many countries. At first it was the actual implement or weapon itself; but in time a conventionalized form was adopted. In West Africa to-day almost the sole currency in many districts has the form of an axe. These are too small now to be actually used, either as weapons of war or as implements of industry; but the shape has been preserved unchanged, and it is evident that the days are not long past when a currency of actual axes was employed.

We have evidence from archæology and from literature of a similar usage among the Greeks. There seems to be little ground for doubting that the earliest coins were imitations in metal of the older article which the metallic currency replaced. Thus, the coins of many Greek states and cities bear on their faces evidence of the nature of the commodity currency they replaced. When the coins were for circnlation among a purely Greek people, there could be no difficulty in passing at once from the commodity to a piece of metal stamped with the image of the article whose value the coin represented. For instance, the Greeks of Cyzicus stamped their coins with the image of a tunny fish which was probably a part of their commodity currency at an earlier date; and these coins are, in most respects, like modern coins. But, in Olbia, a Greek colony on the Black Sea, where the Greeks traded with the barbarians, and the population moreover was of mixed race, the tunny fish was also the chief article of trade. There it was found necessary to make a concession to the lower level of intelligence of those with whom they traded, and perhaps also of many of their own citizens; and consequently a coin in the actual shape of a tunny fish was struck to represent the probable original commodity currency. In the same way the axe appears on the coins of

*Del Mar: A History of Money in Ancient Countries, p. 109.

Tenedos, and there is more than probability that just as the tunny fish coin of Cyzicus represented the earlier form so the axe stamped coins of Tenedos represented an earlier axe currency. We know from the Iliad that axes were given along with oxen, slaves, kettles, etc., as prizes in the funeral games for Patroclus. "But he (Achilles) set for the archers dark iron, and he set down ten axes and ten half axes," Iliad XXIII., ll. 850-1; where the half axe is obviously the single headed axe. The earliest coins of the Island of Tenedos, which lies off the Troad, bear the device of the double headed axe and represent an original axe currency such as we find in Africa to-day.

While the ox undoubtedly formed the unit of value and a medium of exchange over the whole of the wide area from the Straits of Dover to the Himalayas, as indeed in every other region where it can flourish, it was nowhere the sole medium of exchange. In almost every region of which we have any information, there is, or was, a regular scale of value in which the ox was simply the chief unit. Some writers have tried to show that the ox was unsuited for currency purposes, because it was incapable, without the adoption of the Scythian practice of cutting steaks from the flanks of the living animal, or the Celtic practice of bleeding the cattle to make the unleavened bread more nutritious, of sub-division to transact the smaller exchanges; and that their use must quickly on that account have been abandoned. Cattle were unsuitable in many ways, though they had considerable stability and uniformity of value throughout their continental range; but the reason their use as money was given up was not their lack of divisibility, for, as we have said, they never formed more than the principal article in a carefully constructed scale of exchange values.

To this day in the Soudan we find, that while the ox is almost universally the standard of value and the medium of exchange for more valuable articles, each particular district has its own peculiar lower units, generally selected from the articles most in

*For this and the other instances from the Greek coinage which follow, and for many others from which these are selected, see Ridgeway, op. cit., Ch. XII.

demand in the district, or from those which the district has special facilities for producing. In one place it is sticks of salt, in another tobacco, in another cotton thread, in another raw cotton in the pod, in another onions, in another hoes, in another copper rings, beads, shells, etc., and in most districts more than one of them. These are for small change, so to speak. But all of them are recognized submultiples of the standard unit, the ox, as our quarters and ten cent pieces are of the dollar; and in the same way, slaves are in many districts there now, as they were in Homeric times, the larger currency, being recognized multiples of the standard ox.

From Greek coins which have been preserved, it is inferred that the Greeks had the same system. There are traces of it not only in Homer, but on the silver coins themselves. With the introduction of metallic currency, the Greeks equaled the ox with the gold talent, while its submultiples were represented by corresponding silver coins. At first, at least, these silver coins often bore as their stamp the representation of the commodity currency with which they were equaled and which they displaced. In many cases no doubt the image and superscription were religious; but there is no reasonable ground for doubting that in their origin many, perhaps all, of these coins bore on their face the evidence of the particular commodity they had displaced as currency. In some cases the representation was carried so far that the coin reproduced the actual shape of the commodity; and even where the stamp on the coin is of a religious character, there is a striking resemblance between the stamp and the article for which the district was famous. In many cases this correspondence is so clear that it is impossible otherwise to explain the peculiar form and image of the coin.

Thasos, for instance, was famous for its wine; and the wine cup or measure appears on its early coins. The unit of capacity, in the case of wine was the measure, and the measure is stamped on the coins to express the fact that this silver coin, bore the same relation to the gold talent as the actual measure of wine

bore to the original ox unit with which the gold talent had been equaled. The olive, again, was the most important product of Attica, and was probably, as it still actually is in many of the countries bordering on the Mediterranean, whether in the shape of olives or of olive oil, an actual medium of exchange; and the silver coins of Attica which replaced this olive currency most appropriately bore the olive sprig. The cuttle fish was an esteemed dainty by the Greeks, as it is to this day in Naples, and also along the Levant; and the coins of Croton bore its image. The ear of wheat appears on the coins of Metaportum, which grew wealthy because of the agricultural resources of Magna Græcia.

Before the invention or discovery of the art of pottery, man made use of natural shells, and many of the Greek names for earthenware vessels are the names of sea shells. Even after earthenware and wood had replaced these primitive and natural utensils, vessels were fashioned, as can be seen in the museums of antiquities to-day, in the old shapes. Thus there are Greek vases in the British Museum which reproduce the shape of the tortoise, and in the South Sea Islands to this day the natives imitate the tortoise shell in wood and earthenware. The tortoise shell was always specially valued, and in China it was used, and perhaps is still used, to make bowls of great beauty. It is to be expected that we should find, as we do, the tortoise shell standing at the top of the ancient Chinese scale of values. Among the Greeks and other Mediterranean peoples it was also valued; and it was the principal article with which the citizens of Aegina carried on their trade with the Phœnicians. It naturally, therefore, was a unit in their scale, and when the shell and commodity currency was replaced among them, as among the other Greek peoples, by silver coins, they stamped their silver coin with the image of the tortoise. And they took pains to make the coin actually represent the tortoise, for it has a high round upper side with a flat under side and markings to indicate the shell. The scarabs of Egypt, pieces of baked clay or porcelain, cut or moulded in the shape of beetles and tortoises, were in all proba-

bility used as money and represent an earlier shell, probably tortoise shell currency.*

In time the mercantile significance of these symbols was forgotten, and a religious interpretation placed on them. But even in the peculiar deities of a district we may often trace the history of its early commerce; and the religious symbolism of the later coins does not contradict the mercantile significance of the images on the early ones. Early peoples, and later ones, very easily discover grandiose explanations for what in their origin are commonplace facts. To take but one instance. The famous iron money of Sparta, which, according to tradition, Lycurgus caused to be dipped in vinegar while red hot to render it worthless as a commodity, thus to restrain the cupidity of the citizen soldiers, was in all probability not adopted from any ascetic motive. The current explanation was, without doubt, an aetiological myth, a grandiose explanation long after the commonplace event. The iron money was the survival of a time when iron was a favorite article of exchange, as it was in the Homeric age, and as it still is, as we have seen, in Africa to-day. But the Spartans were a very conservative people, and clung to their primitive money long after the superiority of other metals for coinage had been demonstrated by experience; and long after the real origin of their money had been forgotten. To explain their own backwardness, they gave, as so many other peoples have given, a religious and moral sanction to their own lack of progressiveness.†

After the introduction of metallic money there was room for a long process of development. Man had still to determine which of the metals was the most suitable for his purposes; and the actual selection which civilized man has made is the result of the survival of the fittest. There are certain qualities which we have come to look for in money, qualities which all metals seem to possess in a greater degree than any one substance, but qualities which all metals do not possess in the same

*Del Mar: *op. cit.*, p. 147.
†Enc. Brit., *Art.* Money.

degree. These are Utility, Portability, Indestructibility, Homogeneity, Divisibility, Stability of Value, Cognizability. These qualities are possessed in an especial degree by gold and silver, and in a less degree by copper. Iron was used, and is still used in many regions; but it is not the best money material because of its cheapness. It does not contain great value in small bulk, and it is not indestructible. Lead was used in classical times, and is still current in Burmah, but it is too soft to be made into good coins which will retain their stamp and be always cognizable. Tin was early adopted as a money material. It was coined by Dionysius, of Syracuse, who was the first to use it of whom we can speak with certainty; and it has remained in use as a money material ever since. In 1680, Charles II. issued tin farthings, and his example was followed by William and Mary in 1690; and it was employed in Java, Mexico, and elsewhere. But it has the defect of being too soft. Copper, either pure or in alloy, has been extensively employed, and it possesses almost all the qualities requisite, except that it does not contain great value in small bulk, and has comparatively little stability of value. Platinum is in many respects suited for currency purpurposes, but it is in but slight demand, and the stock on hand is very small. Consequently any change in the demand is apt to cause great fluctuations in value. Russia, which owns platinum mines in the Ural Mountains, began to coin it in 1828, but abandoned the experiment in 1845, because of the cost of striking coins. Nickel has been largely used in alloy, but it is subject to the disadvantage of fluctuations in value owing to the limited number of mines. Silver and gold are pre-eminently the metals suitable for coinage. They possess all the qualities necessary in a currency material. These qualities, of course, they do not possess in a perfect degree; but they possess them in a higher degree than any other substances. They have great utility. They contain great value in small bulk and are readily portable. Except by the slow process of wear and tear they are practically indestructible. They are almost perfectly homogenous after they have been reduced to uniform degrees of

fineness, which can be easily done, so that equal weights of them have practically equal values. They can be easily divided into the weights and fractions desired so as to express large values and small values. They have a very large degree of stability of value, not so much perhaps as wheat, but more than most articles which could be employed as money. And lastly, they are readily recognizable and cannot be easily counterfeited, and above all, are soft enough and yet hard enough to be coinable, "so that a portion, being once issued according to proper regulations with the impress of the state, may be known to all as good and legal currency equal in weight, size and value to all similarly marked currency."*

The precious metals are simply those commodities which experience has shown to be the most suitable for general money purposes. This, or that money article, may have this or that money quality in a higher degree than gold or silver, but taking them all in all, the precious metals have been found to be the most suitable. They have survived, not because of any prejudice in favor of the metals, but because they have shown themselves to be the fittest to survive.

*Jevons: Money and the Mechanism of Exchange, p. 40.

VI.—On the Presence of Acid Sulphate of Copper in Mixtures of Aqueous Solutions of Sulphuric Acid and Copper Sulphate.—By Charles F. Lindsay, *Dalhousie College, Halifax, N. S.*

(Communicated on 8th May, 1899, by Prof. E. Mackay, Ph. D.)

Anton Schrader* in a paper on the "Electrolysis of Mixtures," measured the conductivity and other properties of solutions containing mixtures of sulphuric acid and copper sulphate, analysing his mixtures for the amount of acid present by titration. In his paper, no methods of any kind are given for the analyses. Prof. MacGregor† has held that Schrader's results point towards the presence of acid sulphate of copper in the solution. At the suggestion of Prof. Mackay this work was undertaken to find if any light could be obtained on this question by chemical analytical methods.

The work was carried out in the Chemical and Physical laboratories of Dalhousie College, and consisted primarily in making up solutions of sulphuric acid and copper sulphate, analysing them, and determining their densities. In the beginning the densities were taken only as a means of calculating the concentration of the mixtures from the concentration of the simple solutions. The work also included the purification of the materials used, and the calibration of burettes and pipettes.

Calibration of Burettes and Pipettes.

All burettes and pipettes were carefully calibrated, by weighing the amount of water of known temperature which they delivered. The burettes used could be read to .01 c.c. They were calibrated for every 2 c.c. throughout their length.

The pipettes, in emptying, were held against the side of the vessel into which they were being emptied, the last drops of water being removed by blowing sharply once.

* Inaugural Dissertation, Berlin, 1897.

† Trans. Roy. Soc. Canada, (2), 4, Sec. 3, 117, 1898-9.

Purification and Analysis of Copper Sulphate.

The copper sulphate was obtained as chemically pure, and after careful re-crystallization, was found to be free from iron and the members of the ammonium sulphide group.

The copper sulphate solutions were analysed by precipitating the sulphate, in known volume, with barium chloride, and weighing as barium sulphate.

The following are the results of three analyses of the same solution :—

$Cu\ SO_4$ in 5 c.c. of solution	= .5782	grammes.
" " "	= .5788	"
" " "	= .5790	"
Mean..........	= .5787	"

These figures would seem to show that my results might be in error about 0.1 per cent.

Purity and Analysis of Sulphuric Acid.

The sulphuric acid was the best obtainable from Merck, and was taken as chemically pure. The sulphuric acid solutions were analysed volumetrically with standard caustic potash, using as an indicator phenol phthalein.

The following results show with what accuracy such analyses could be carried out :—

2 c.c. $H_2\ SO_4$ solution contained	.1627	grammes	$H_2\ SO_4$
" " " "	.1625	"	"
" " " "	.1624	"	"
Mean.......... =	.16253	"	"

Thus, the possible error of a single measurement would seem to be about 0.11 per cent.

Preparation and Analysis of Mixtures.

Equal volumes of the simple solutions, whose concentrations and densities were known, were mixed at 18°C. The density of the mixture being obtained, the concentration of the mixture with respect to each of the constituents, was obtainable.

The ordinary methods of acid titration are, of course, unavailable in this case, for not only does the copper sulphate itself affect alkalimetric indicators, but the sulphate is precipitated as hydroxide, by the base used for titration. The latter fact is the one used in the method of titration which was employed.

Standard caustic potash solution is added from a burette to the mixture, with constant stirring, until the solution just begins to become cloudy, owing to the beginning of the precipitation of the hydroxide of copper. I found that, using this precipitating point as an indicator, very good determinations of the acid present could be obtained, and would suggest that copper sulphate might be used as an indicator in the determination of free sulphuric acid, in cases where the ordinary indicators are of no use.

The following results of an analysis will show with what accuracy the determination of this precipitating point could be ascertained:

5 c.c. of a mixture $CuSO_4 + H_2SO_4$, began to be cloudy on addition of 43.88 c.c. decinormal caustic potash.

43.97 " " "
43.99 " " "
44.86 " " "

43.92 = mean.

Thus, in these determinations, the difference between the greatest and least values would be about .3%.

A second set of determinations is added:

5 c.c. of a mixture $CuSO_4 + H_2SO_4$, began to become cloudy on addition of 28.94 c.c. of decinormal caustic potash.

28.91 " " " "
28.99 " " " "

28.95 = mean

In this case, the difference between the greatest and least values is about .27%.

It is thus seen not only that the precipitating point is a perfectly definite one, but that it can be determined with considerable accuracy.

The next question is, whether it expresses accurately the amount of acid present.

Concentration.		H_2SO_4		Error.
H_2SO_4	$CuSO_4$	Calculated.	Found.	
.416	.364	.2036	.2039	+.15%
.277	.727	.1356	.1357	+.08%

Column I. contains the concentration of H_2SO_4 in mixture in gramme-molecules per litre.

" II. contains the concentration of $CuSO_4$ in mixture in gramme-molecules per litre.

" III. contains the amt. of H_2SO_4 in grammes, calculated to be in every 5 c.c. of mixture.

" IV. contains the same, as found in every 5 c.c. of mixture.

" V. contains the percentage error.

We thus see that by this means, the sulphuric acid present can be determined with considerable accuracy.

In the above analyses, the mixture under analysis was diluted very much, the reason being, that so far the work has been only to find a good method of analysis, and not to prove or disprove the presence of acid sulphate.

But now a number of analyses were performed on the above mixtures, keeping the mixtures concentrated, and in no case was there any appreciable difference in the amount of caustic potash needed before precipitation would commence.

The results obtained from analyses of the concentrated mixtures, gave, as a rule, slightly less quantities of sulphuric acid. But this I would attribute to the fact that the precipitate would be more easily noticed in the smaller volume than in the larger.

I also made a number of determinations, using standard ammonia in place of the standard potash, but although the precipitating point could be fairly well determined, the results did not agree as well with the amount of sulphuric acid known to be present.

We thus see that this method of chemical analysis for sulphuric acid, while it gives us a good method of analysis for such mixtures, sheds no light on the presence of acid sulphate in solution.

While any recognizable decrease in the amount of sulphuric acid given up to analysis from that known to be present, would yield an almost conclusive proof of the presence of acid sulphate, the result obtained here, does not of necessity lead to the reverse conclusion.

Specific Gravity Measurements.

All specific gravity measurements were made at 18°, and are referred to water at 18°. In these measurements, a pycnometer of the form recommended by Ostwald, and holding about 25 c.c. was used.

The pycnometer was brought to 18° by being placed in a water bath, provided with a mechanical stirrer, whose temperature could easily be kept constant to 1/20 of a degree. When the liquid had come to the temperature of the bath, the meniscus was brought to the mark, the pycnometer taken out, dipped in distilled water, dried carefully with a linen towel, and weighed.

From several successive measurements of the same solution, it would appear that my measurements of density might be in error by about 5 in the fifth place of decimals.

Favre and Valson* have found that, in the case of concentrated solutions of K_2SO_4 and $CuSO_4$, and K_2SO_4 and H_2SO_4, the density of a mixture of equal volumes of the constituents, is less than the mean value of their densities. From these results they

*Compt. Rend., 77, 907.

drew the conclusion that acid or double sulphate was present in solution. Also McKay† has noticed the same for mixtures of potassium and magnesium sulphates.

In the case of more concentrated solutions of $CuSO_4$ and H_2SO_4, I have found the same result to hold. But from lack of time I was unable to push this far.

I give two of my measurements, showing the concentration and density of the constituents, the density of the mixture, and its departure from the mean value.

Parts of H_2SO_4 in 100 parts Sol'tion.	Parts of $CuSO_4$ in 100 parts Sol'tion.	Density H_2SO_4	Density $CuSO_4$.	Mean Value.	Density of Mixture.	Difference.
17.41	16.083	1.12586	1.19108	1.15842	1.15603	.00239
16.23	13.877	1.11525	1.14802	1.13163	1.12952	.00211

† Trans. N. S. Inst. Sci., 9, 348, 1897-98.

VII.—On a Diagram of Freezing-Point Depressions for Electrolytes.—By Prof. J. G. MacGregor, *Dalhousie College, Halifax, N. S.*

(Received June 20th, 1900.)

The object of this paper is to describe a diagrammatic method of taking a bird's-eye view of such knowledge as we possess of the relation of the depression of the freezing-point to the state of ionization in aqueous solutions of electrolytes, and to show that such diagrammatic study gives promise of throwing much light upon the following questions: (1.)*—Has the depression constant a common value for all electrolytes, and if so, what is it? And (2), What is the state of association, and what the mode of ionization of electrolytes, in solution?

Construction and Properties of the Diagram.

If an extremely dilute solution contain an electrolyte whose molecule, as it exists in solution, contains p equivalents, and dissociates into q free ions, and if a is its ionization coefficient and k its depression constant, the equivalent depression will be:

$$\delta = \frac{k}{p}\Big(1 + a\,(q-1)\Big).$$

If therefore we plot a diagram of curves with ionization coefficients as ordinates, and equivalent depressions as abscissae, the resulting curves must, at extreme dilution ($a = 1$), be tangential to the straight lines represented by the above equation, provided the proper values of k, p, and q be employed. These straight lines, which, for shortness, we may call the tangent lines of the curves, can readily be drawn in the diagram, with any assumed value of k, and on any admissible assumptions as to the values of p and q. In the diagram on page 235 the dashed lines are the

* On this question, see also a paper recently communicated to the Royal Society of Canada, and to be published in its Transactions for 1900.

tangent lines for the electrolytes examined, on various assumptions as to constitution in solution and mode of ionization, and for $k=1.85$. They are indicated by the inscriptions 1—2, 2—3, etc., the first figure in each giving the number of equivalents in the molecule as it is assumed to exist in solution, and the second, the number of free ions into which the molecule is assumed to dissociate. Thus 1—2 is the tangent line for an electrolyte such as NaCl, on the assumption that it exists in solution in single molecules, each of which has therefore 1 equivalent, and dissociates into 2 ions. If assumed to associate in double molecules, with unchanged mode of ionization, its tangent line would be indicated by 2—4, and if the double molecules were assumed to dissociate into Na and $NaCl_2$, by 2—2. The line for H_2SO_4, on the assumption that its molecules undergo no association, and have thus 2 equivalents, and that they dissociate each into 3 ions, would be 2—3; and 4—6 would be its line if it associated into double molecules, dissociationg each into 6 ions.

In a few cases dotted lines have been introduced, to show what the tangent lines would be with other values of k,—1.83, 1.84, 1.86, 1.87, the constant used in such cases being indicated.

The curve for any given electrolyte, must start at the intersection of its tangent line with the line: $a=1$, to which point we may refer, for shortness, as the intersection of its tangent line. What its form will be, may be anticipated from the following theoretical considerations:—The equivalent depression in dilute solutions of non-electrolytes, is proportional to the osmotic pressure, P, and the dilution, V, which corresponds to the product of the pressure, p, and the specific volume, v, in the case of a gas. If pv is plotted against v, the resulting curve is convex towards the axis of v, and passes, in general, through a point of minimum value of pv. Hence, if PV, and therefore equivalent depression, be plotted against V, we may expect to get curves of the same general form. And experiment shows, in some cases at least, that we do. As in the case of gases the variation of pv is ascribed to the mutual action of the molecules and their finite volume, so in the case of solutions, the variation of PV is attributed to similar disturbing influences.

Owing to ionization, the curve of an electrolyte will differ from that of a non-electrolyte, (1) because of the change thereby produced in the number of molecules (including free ions) in unit of volume, and (2) because of the change produced in the disturbing influences referred to. The former change is doubtless the more important, and I shall assume the latter to be negligible for the present purpose. Now dissociation increases continuously with dilution. If, therefore, association of molecules does not occur, and if the mode of ionization does not change, the equivalent depression must be increased by the dissociation, in a ratio which increases continuously with dilution. The change produced in the curve by dissociation, therefore, will be a shear parallel to the equivalent depression axis, and increasing with dilution. The resulting curve will consequently remain convex towards the axis of dilution, but it will be less likely than the curve of a non-electrolyte, to exhibit the minimum point.

If, now, we plot equivalent depression against ionization coefficient, instead of dilution, the result will be the same as if we shortened the dilution ordinates of the various points of the curve just mentioned, in ratios increasing with the dilution, which process must leave the curve convex towards what was the dilution axis, but is now the ionization coefficient axis.

If, therefore, no change occur in the association of molecules or in the mode of ionization, the curve of an electrolyte on the diagram must start at the intersection of its tangent line, tangentially to that line, and bend away from it, as dilution diminishes, to the right, possibly passing through a point of minimum equivalent depression. We may speak of such a curve as the normal curve for the tangent line, corresponding to the given conditions as to constitution in solution, and mode of ionization.

If, the constitution of the electrolyte in the solution remaining constant, the mode of ionization changes as dilution diminishes, say, in such a way that the molecules dissociate, on the average, into a smaller number of ions, the equivalent depression will diminish more rapidly than it otherwise would. The curvature of the curve will therefore diminish, and may possibly become

zero, and change sign, the curve thus becoming concave towards the ionization coefficient axis, and possibly crossing the tangent line. In such a case, it will at the start coincide with the normal curve of the tangent line determined by the initial conditions as to association and mode of ionization, and at the finish, with the normal curve of the tangent line, determined by the final conditions; and between the start and the finish it will gradually change from the one to the other.

If, as dilution diminishes, association of molecules into double or other multiple molecules occurs, the mode of ionization remaining the same, the equivalent depression will be thereby made to diminish more rapidly than it otherwise would, and the general effect on the form of the curve, will be of the same kind as under the conditions just considered. But the normal curves of the tangent lines determined by the final conditions, will be quite different in the two cases.

It follows that by plotting, so far as experiment allows, the curves of observed equivalent depression against ionization coefficient, and drawing in the tangent lines for different values of the depression constant, and on different assumptions as to association and mode of ionization, we may be able to determine, with a smaller or greater probability, what the state of association and the mode of ionization are, what are the tangent lines to whose intersections the curves would run out if observations at extreme dilution could be made, and what the values of the depression constant are, to which these lines correspond.

Data for the Diagram.

To draw the experimental curves, we must have corresponding values of the depression, and of the ionization coefficient, at the freezing point, or, what in most cases would be sufficiently near, at 0°C. The former are obtained by direct measurement; but the latter only indirectly, from conductivity observations. It is not, of course, known how closely the ionization coefficients, even during the passage of the current, can thus be determined, or if the state of ionization during the passage of the

current is to be regarded as being the same as when the current is not flowing. But as it has been shown that electrically determined coefficients enable us to predict within the limit of error of observation, not only the conductivity and the results of electrolysis* of moderately dilute complex solutions, but also their density, viscosity, and other non-electrical properties,† it would appear to be probable that for moderately dilute and very dilute solutions, electrically determined coefficients are approximately exact, not only for a solution through which a current is passing, but generally.

The available data as to ionization coefficients at 0°, are unfortunately few. Whetham† has recently published some most valuable determinations, having measured the conductivity at 0°, of series of solutions down to extreme dilution, with what one may call *appareil de luxe,* and found the ratio of the equivalent conductivity to the maximum equivalent conductivity. For neutral salts, his coefficients must inspire great confidence. But in the case of the acids, they seem to me to be probably too high. For the maximum equivalent conductivity of an acid is probably lower than it would be, were it not for the disturbing influence whatever it is, which makes the equivalent-conductivity-concentration curve not only reach, but pass through a maximum point.

Archibald and Barnes,‡ working in my laboratory, measured the conductivity at 0° and 18° for series of solutions, down to dilutions, at which the ratio of the two conductivities became constant; and assuming that the same ratio would hold at extreme dilution, they calculated the equivalent conductivity at extreme dilution for 0° from Kohlrausch's values for 18°. They used this method only because appliances were not available, with which observations at extreme dilution could be made. If

* MacGregor: Trans. Roy. Soc. Can. (2), 4, Sec. 3, 117, 1898.

† MacGregor: Trans. N. S. Inst. Sci. 9, 219, 1896-7, and Phil. Mag. (5), 43, 46 and 99, 1897. Also Archibald: Trans. N. S. Inst. Sci. 9, 335, 1897-8, and Barnes: *Ibid.*, 10, 49, and 113, 1899-1900.

† Ztschr. f. phys. Chem., 33, 344, 1900.

‡ Archibald: Trans. N. S. Inst. Sci., 10, 33, 1898-9. Barnes: *Ibid.*, 10, 139, 1899-1900, and Trans. Roy. Soc. Canada, (2), 6, —, 1900.

the ratio mentioned really does become constant as dilution increases, the method is likely to give coefficients with too low or too high values, according as the ratio at moderate dilutions diminishes or increases with dilution (it was found to increase with KCl and K_2SO_4.) For it will probably become constant within the limit of error of observation, before it has really reached constancy. And if it changes with dilution in a slightly wavy manner, even though on the whole tending to constancy, it may be regarded as having become constant, when really passing through a maximum or a minimum point.

Déguisne's* observations on the variation of conductivity with temperature between 2°C and 34° have enabled me, by the method just mentioned, to make rough determinations of the ionization coefficients at 0° in some cases, on the assumption that his empirical constants might be used down to 0°. According to Déguisne's observations, the ratio of the conductivities at 0° and 18° usually changes gradually down to dilutions of 1,000 litres per gramme-equivalent, and between that and 2,000, undergoes rapid change. As observations at great dilution are attended by considerable difficulty, I have assumed that these sudden changes were probably due to errors of observation. If they were not, my Déguisne coefficients (for which Déguisne himself is of course not to be held responsible) may be considerably out.

In some cases, I have obtained coefficients from the above data by extrapolation, in order to make use of available depression data. In such cases I have plotted, side by side, ionization-coefficient-concentration curves, for both 0° and 18°, using values for 18° based on Kohlrausch's conductivities, and I have then produced the 0° curve beyond the limit of observation, under the guidance of the 18° curve.

I have used all the accessible observations of depression in the case of the electrolytes for which data were available for detering the ionization coefficients at 0°, including observations by

---

* Temperatur-Coëfficienten des Leitvermögens sehr verdünnter Lösungen, Dissertation, Strassburg, 1895. See also Kohlrausch u. Holborn: Leitvermögen der Elektrolyte, Leipzig, 1898.

Arrhenius,[1] Raoult,[2] Loomis,[3] Jones,[4] Abegg,[5] Wildermann,[6] Ponsot,[7] Archibald[8] and Barnes[8]. The methods used by these observers are, for the most part, well known. Archibald and Barnes used modified forms of Loomis's method. Arrhenius's observations, and some of Raoult's, were made before important improvements in freezing-point determinations had been recognised as necessary.

In cases in which there was but one series of observations available, I have plotted the actual observations in the diagram, though sometimes smoothing the curves a little. In cases in which two or more series were available, I first plotted the various observations, and then drew mean curves, making them represent all the observations as well as I could, but giving greater weight to recent observations than to those of earlier date, and to long series of consistent observations than to short series, or to series which were more erratic.

The following table gives the data employed in plotting both the curves given in the diagram, and those not so given, which are referred to below. The table includes the concentration in gramme-equivalents per litre, the ionization coefficient at 0°, and the equivalent depression in degrees centigrade per gramme-equivalent in one litre of solution. The interpolated coefficients are indicated by *i*, and those extrapolated by *e*, and the observers from, or by the aid of, whose observations they were obtained, by A, B, D, W, representing Archibald, Barnes, Déguisne and Whetham. Non-significant figures are printed in italics.

---

[1] Ztschr. f. phys. Chemie. 2, 491. 1888.

[2] *Ibid.*, 2, 501, 1888, and 27, 617, 1898.

[3] Phys. Review, 1, 199 and 274, 1893-4; 3, 270, 1896, and 4, 273, 1897.

[4] Ztschr. f. phys. Chem., 11, 110 and 529, 1893; and 12, 623, 1893.

[5] *Ibid.* 20, 207, 1896.

[6] *Ibid.* 19, 233, 1896.

[7] Recherches sur la Congélation des Solutions Aqueuses: Paris, Gauthier-Villars, 1896.

[8] *Loc. cit.*

KCl. (Barnes.)

Gramme-equivalent per litre.	Ionization Coefficient at 0°C.	Equivalent Depression.
.0001	.989	....
.0002	.986	....
.0005	.977	....
.001	.971	....
.005	.944	....
.010	.930	....
.03	.910	3.533
.05	.892	3.504
.08	.871	3.470
.10	.862	3.458
.20	.832	3.398
.30	.819	3.390
.40	.804	3.372

KCl. (Loomis.)

Gramme-equivalent per litre.	Ionization Coefficient at 0°C.	Equivalent Depression.
.01	.943 i. B.	3.60
.02	.923 "	3.55
.03	.910 "	3.52
.035	.905 "	3.53
.05	.892 "	3.50
.1	.862 "	3.445
.2	.832 "	3.404
.4	.804 "	3.353

KCl. (Jones.)

Gramme-equivalent per litre.	Ionization Coefficient at 0°C.	Equivalent Depression.
.001	.992 i. W.	3.80
.00299	.983 "	3.6789
.00499	976 "	3.7074
.00698	.970 "	3.6246
.00897	.965 "	3.6120
.01095	.960 "	3.5982
.02	.944 "	3.5750
.04	.897 i. B.	3.5325
.0592	.885 "	3.5067
.078	.873 "	3.4923
.09646	.863 "	3.4688
.2	.832 "	3.4300
.28	.821 "	3.41071

KCl. (Raoult.)

Gramme-equivalent per litre.	Ionization Coefficient at 0°C.	Equivalent Depression.
.01445	.953 i. W.	3.523
.02895	.933 "	3.561
.05825	.904 e. W.	3.478
.1168	.878 "	3.431

KCl. (Abegg.)

Gramme-equivalent per litre.	Ionization Coefficient at 0°C.	Equivalent Depression.
.00488	.976 i. W.	3.70
.00972	.962 "	3.63
.0118	.958 "	3.64
.0145	.953 "	3.63
.0193	.944 "	3.53
.0237	.917 i. B.	3.51
.0240	.917 "	3.49
.0286	.912 "	3.51
.0354	.904 "	3.50
.0469	.895 "	3.47
.0583	.887 "	3.45
.0697	.878 "	3.43

KCl. (Wildermann.)

Gramme-equivalent per litre.	Ionization Coefficient at 0°C.	Equivalent Depression.
.009818	.943 i. B.	3.538
.009822	.943 "	3.583
.01954	.924 "	3.542
.03883	.900 "	3.515
.03884	.900 "	3.532
.07652	.873 "	3.491
.07668	.873 "	3.487

KCl. (Ponsot.)

Gramme-equivalent per litre.	Ionization Coefficient at 0°C.	Equivalent Depression.
.0234	.915 i. B.	3.419
.0439	.896 "	3.417
.1468	.846 "	3.413
.1688	.840 "	3.406
.2344	.827 "	3.392
.2456	.825 "	3.375
.2472	.825 "	3.378
.2544	.824 "	3.377

NaCl. (Barnes.)

Gramme-equivalent per litre.	Ionization Coefficient at 0°C.	Equivalent Depression.
.0001	.996	....
.0002	.991	....
.0005	.982	....
.001	.974	....
.005	.955	....
.010	.936	....
.03	.896	3.573
.05	.877	3.536
.08	.860	3.530
.10	.850	3.515
.20	.815	3.443
.30	.787	3.431
.40	.765	3.412

Gramme-equivalent per litre.	Ionization Coefficient at 0°C.	Equivalent Depression.
NaCl. (Loomis.)		
.01	.936 i. B.	3.674
.02	.916 "	3.597
.03	.896 "	3.560
.04	.886 "	3.541
.05	.878 "	3.531
.06	.870 "	3.529
.07	.864 "	3.510
.08	.860 "	3.501
.09	.855 "	3.494
.10	.850 "	5.484
.20	.815 "	3.439
NaCl. (Jones.)		
.001	.974 i. B.	3.7500
.002	.967 "	3.7500
.002999	.963 "	3.683
.004	.959 "	3.650
.004998	.955 "	3.681
.005995	.950 "	3.678
.006995	.947 "	3.631
.007985	.942 "	3.628
.008985	.939 "	3.628
.01	.936 "	3.605
.02	.915 "	3.578
.0298	.896 "	3.544
.0395	.887 "	3.538
.04955	.878 "	3.519
.05975	.870 "	3.507
.0697	.865 "	3.500
.0790	.861 "	3.492
.0882	.856 "	3.483
.0973	.851 "	3.477
.1063	.848 "	3.469
.15	.831 "	3.447
.1925	.818 "	3.418
.2329	.805 "	3.414
.300	.787 "	3.410
NaCl. (Raoult.)		
.0300	.896 i. B.	3.656
.0584	.870 "	3.550
.1174	.843 "	3.473
.2370	.804 "	3.465

Gramme-equivalent per litre.	Ionization Coefficient at 0° C.	Equivalent Depression.
NaCl. (Abegg.)		
.00241	.965 i. B.	3.91
.00478	.956 "	3.91
.00714	.945 "	3.84
.00948	.937 "	3.82
.01180	.931 "	3.70
.01410	.925 "	3.66
.0221	.906 "	3.56
.0439	.882 "	3.57
.0653	.867 "	3.55
.0871	.856 "	3.50
.1083	.847 "	3.47
NaCl. (Arrhenius.)		
.0467	.879 i. B.	3.79
.117	.843 "	3.64
.194	.816 "	3.54
.324	.781 "	3.51
NaCl. (Ponsot.)		
.1318	.836 i. B.	3.445
.1808	.821 "	3.418
.2016	.814 "	3.413
.2248	.808 "	3.403
.2288	.806 "	3.405
.3136	.784 "	3.402
HCl. (Barnes.)		
.001	.996	....
.002	.995	....
.005	.989	....
.010	.984	....
.0207	.971	3.638
.0518	.955	3.595
.0829	.941	3.569
.104	.932	3.556
.207	.909	3.585
.305	.897	3.633
.40	.884	3.638

Gramme-equivalent per litre.	Ionization Coefficient at 0° C.	Equivalent Depression.
HCl. (Loomis.)		
.01	.982 i. B.	3.61
.02	.972 "	3.60
.05	.955 "	3.59
.1	.933 "	3.546
.2	.910 "	2.565
.3	.897 "	3.612
HCl. (Jones.)		
.001222	.996 i. B.	3.7643
.003662	.991 "	3.7411
.006112	.987 "	3.7467
.008538	.984 "	3.7033
.01222	.979 "	3.6743
.03619	.962 "	3.6750
.05919	.951 "	3.6611
.08127	.940 "	3.5856
.1025	.933 "	3.5609
.1228	.928 "	3.5692
NH_4Cl. (Loomis.)		
.01	.951 i. D.	3.56
.02	.931 "	3.56
.035	.914 "	3.50
.05	.900 "	3.48
NH_4Cl. (Jones.)		
.001	.987 i. D.	3.8
.00599	.963 "	3.7062
.00997	.951 "	3.6108
.0595	.892 e. D.	3.5143
KNO_3. (Loomis.)		
.01	.938 i. D.	3.46
.02	.915 "	3.52
.025	.899 "	3.46
.05	.876 "	3.41
.1	.832 e. D.	3.314
.2	.789 "	3.194

Gramme-equivalent per litre.	Ionization Coefficient at 0° C.	Equivalent Depression.
HNO_3. (Loomis.)		
.01	.977 i. D.	3.50
.02	.967 e. D.	3.56
.03	.959 "	3.53
.05	.950 "	3.51
HNO_3. (Jones.)		
.001054	.994 i. D.	3.7951
.003158	.989 "	3.7682
.005253	.982 "	3.7693
.007378	.981 "	2.7409
.009456	.978 "	3.7331
.01153	.975 e. D.	3.7294
.03119	.958 "	3.7179
.05103	.949 "	3.7076
KOH. (Loomis.)		
.01	.965 i. D.	3.43
.02	.956 e. D.	3.45
.05	.943 "	3.44
.1	.932 "	3.43
KOH. (Jones.)		
.001069	.983 i. D.	3.7418
.003202	.973 "	3.7477
.005327	.969 "	3.7169
.007443	.967 "	3.6947
.009550	.965 "	3.6859
.01069	.964 e. D.	3.6296
.03163	.950 "	3.6263
.05174	.942 "	3.5756
.07481	.935 "	3.6142
$BaCl_2$. (Loomis.)		
.02	.860 i. W.	2.495
.04	.820 e. W.	2.475
.1	.768 "	2.385
.2	.724 "	2.345
.4	.658 "	2.3275

$BaCl_2$. (Jones.) *

Gramme-equivalent per litre.	Ionization Coefficient at 0° C.	Equivalent Depression.
.002	.953 i. W.	2.7500
.003996	.932 "	2.7027
.005988	.917 "	2.6720
.008	.906 "	2.6250
.009984	.896 "	2.6142
.011964	.889 "	2.5828
.01394	.880 "	2.5753
.01592	.872 "	2.5754
.01788	.866 "	2.5560
.02	.860 "	2.5500

$BaCl_2$. (Ponsot.)

Gramme-equivalent per litre.	Ionization Coefficient at 0° C.	Equivalent Depression.
.00926	.900 i. W.	2.484
.00994	.897 "	2.515
.01030	.895 "	2.524
.01290	.887 "	2.481
.01304	.883 "	2.531
.02500	.845 "	2.480
.02740	.839 "	2.482
.03310	.827 e. W.	2.477
.03588	.822 "	2.481
.03676	.820 "	4.475
.03824	.818 "	2.458
.04810	.803 "	2.453
.05112	.802 "	2.445
.05520	.796 "	2.446
.0620	.790 "	2.436
.0680	.785 "	2.426
.0774	.771 "	2.416
.2060	.717 "	2.316
.2095	.716 "	2.320
.2235	.710 "	2.309
.3100	.685 "	2.297
.3280	.682 "	2.308
.3470	.679 "	2.317

K_2SO_4. (Archibald.)

Gramme-equivalent per litre.	Ionization Coefficient at 0° C.	Equivalent Depression.
.0001	.983	....
.0002	.976	....
.0004	.969	....
.0005	.964	....
.0006	.960	....
.0008	.953	....
.001	.946	....

K_2SO_4. (Archibald.)—*Continued.*

Gramme-equivalent per litre.	Ionization Coefficient at 0° C.	Equivalent Depression.
.002	.925	....
.004	.904	....
.005	.895	....
.008	.871	....
.010	.859	....
.050	.755	2.370
.055	.748	2.356
.060	.743	2.345
.070	.732	2.327
.080	.722	2.314
.100	.705	2.285
.200	.645	2.161
.250	.629	2.118
.300	.616	2.080
.350	.606	2.056
.400	.598	2.032
.450	.591	2.014
.500	.588	1.990
.600	.583	1.950
.700	.580	1.916

K_2SO_4. (Loomis.)

Gramme-equivalent per litre.	Ionization Coefficient at 0° C.	Equivalent Depression.
.02	.821 i. A.	2.46
.04	.772 "	2.38
.1	.705 "	2.271
.2	.645 "	2.1585
.4	.59$ "	2.0335
.6	.583 "	1.9455

K_2SO_4. (Jones.)

Gramme-equivalent per litre.	Ionization Coefficient at 0° C.	Equivalent Depression.
.002	.925 i. A.	2.725
.003992	.904 "	2.693
.005990	.886 "	2.663
.007970	.871 "	2.641
.009930	.859 "	2.613
.012	.850 "	2.613
.01396	.842 "	2.593
.01590	.836 "	2.582
.01784	.829 "	2.545
.01976	.823 "	2.525
.03949	.771 "	2.469
.0579	.745 "	2.413
.07556	.727 "	2.372
.10	.705 "	2.307

* I have by oversight used one of Jones' two sets of observations, instead of the mean of his two sets ; but the curve of mean values would not differ appreciably from the curve of single values.

Gramme-equivalent per litre.	Ionization coefficient at 0° C.	Equivalent Depression.
K_2SO_4. (Jones.)—*Continued.*		
.116	.692 i. A.	2.289
.1357	.677 “	2.231
.152	.668 “	2.208
.16765	.661 “	2.197
.1826	.624 “	2.178
.19685	.647 “	2.160
K_2SO_4. (Abegg)		
.00876	.865 i. A.	2.79
.01306	.846 “	2.60
.01734	.829 “	2.47
.0216	.815 “	2.43
.0258	.803 “	2.40
.0299	.794 “	2.385
K_2SO_4. (Arrhenius.)		
.0728	.729 i. A.	2.53
.182	.654 “	2.225
.454	.590 “	2.09
K_2SO_4. (Ponsot.)		
.0724	.731 i. A.	2.307
.0752	.726 “	2.301
.2295	.635 “	2.113
.2360	.633 “	2.110
.4140	.596 “	2.012
.4280	.594 “	2.002
Na_2SO_4. (Archibald.)		
.005	.893	....
.008	.870	....
.010	.859	....
.050	.752	2.382
.055	.743	2.371
.060	.736	2.360
.070	.722	2.340
.080	.712	2.320
.100	.694	2.286
.200	.624	2.165

Gramme-equivalent per litre.	Ionization coefficient at 0° C.	Equivalent Depression.
Na_2SO_4. Archibald.—(*Continued.*)		
.250	.600	2.120
.300	.578	2.084
.350	.561	2.045
.400	.546	2.025
.450	.535	1.993
.500	.525	1.975
.600	.511	1.925
.700	.501	1.890
Na_2SO_4. (Loomis.)		
.02	.821 i. A.	2.545
.04	.771 “	2.435
.10	.694 “	2.295
.20	.624 “	2.170
.40	.546 “	2.036
.60	.511 “	1.938
Na_2SO_4. (Raoult.)		
.1174	.678 i. A.	2.39
.2866	.584 “	2.18
.426	.540 “	2.68
Na_2SO_4. (Arrhenius.)		
.056	.741 i. A.	2.515
.1402	.661 “	2.325
.234	.607 “	2.205
.390	.549 “	2.095
H_2SO_4. (Barnes.)		
.002	.883	....
.004	.831	....
.010	.783	....
.020	.734	....
.0406	.720	2.224
.1016	.644	2.084
.1622	.609	2.017
.204	.596	1.979
.406	.569	1.940
.608	.553	1.918

H_2SO_4. (Loomis.)

Gramme-equivalent per litre.	Ionization Coefficient at 0° C.	Equivalent Depression.
.02	.770 i. B.	2.247
.04	.721 "	2.155
.10	.645 "	2.065
.20	.598 "	1.984
.40	.570 "	1.925

H_2SO_4. (Jones.)

Gramme-equivalent per litre.	Ionization Coefficient at 0° C.	Equivalent Depression.
.002696	.962 i. W.	2.7077
.007182	.906 "	2.5620
.011650	.870 "	2.5150
.016106	.844 "	2.4091
.02054	.823 "	2.3710
.02696	.796 "	2.3108
.07100	.678 i. B.	2.2183
.11358	.633 "	2.0514
.15472	.612 "	1.9952
.19450	.598 "	1.9732
.2330	.586 "	1.9498

H_2SO_4. (Ponsot.)

Gramme-equivalent per litre.	Ionization Coefficient at 0° C.	Equivalent Depression.
.0149	.790 e. B.	2.282
.0181	.770 "	2.265
.0365	.726 "	2.192
.0395	.720 i. B.	2.203
.0503	.706 "	2.147
.0669	.681 "	2.108
.0727	.674 "	2.091
.0876	.658 "	2.043
.2570	.587 "	1.895
.2580	.587 "	1.899
.4476	.565 "	1.850
.4516	.565 "	1.849
.8872	.535 "	1.859

H_2SO_4. (Wildermann.)

Gramme-equivalent per litre.	Ionization Coefficient at 0° C.	Equivalent Depression.
.009208	.889 i. W.	2.422
.009216	.889 "	2.388
.016808	.842 "	2.297
.016834	.842 "	2.293
.01690	.840 "	2.325
.03206	.776 "	2.190
.03212	.735 i. B.	2.183
.06238	.688 "	2.10

H_2SO_4. (Wildermann.)—*Continued.*

Gramme-equivalent per litre.	Ionization Coefficient at 0° C.	Equivalent Depression.
.06244	.688 i. B.	2.098
.09216	.653 "	2.049
.1358	.622 "	2.004
.1930	.599 "	1.970

Na_2CO_3. (Loomis.)

Gramme-equivalent per litre.	Ionization Coefficient at 0° C.	Equivalent Depression.
.02	.735 i. D.	2.535
.04	.684 "	2.465
.10	.611 e. D.	2.32

Na_2CO_3. (Jones.)

Gramme-equivalent per litre.	Ionization Coefficient at 0° C.	Equivalent Depression.
.003030	.859 i. D.	2.805
.008068	.803 "	2.764
.013090	.770 "	2.758
.018096	.743 "	2.741
.02120	.730 "	2.722
.04802	.670 "	2.676
.07736	.632 e. D.	2.494
.09588	.613 "	2.335

$MgSO_4$ (Loomis.)

Gramme-equivalent per litre.	Ionization Coefficient at 0° C.	Equivalent Depression.
.02	.594 i. D.	1.331
.04	.522 "	1.277
.06	.485 "	1.237

$MgSO_4$ (Jones.)

Gramme-equivalent per litre.	Ionization Coefficient at 0° C.	Equivalent Depression.
.002	.817 i. D.	1.7000
.003996	.773 "	1.6767
.005998	.728 "	1.6533
.007976	.694 "	1.6174
.009960	.669 "	1.6064
.011994	.651 "	1.5913
.01400	.634 "	1.5785
.015972	.614 "	1.5590
.017940	.608 "	1.5496
.019904	.596 "	1.5323
.03950	.521 "	1.4912
.05872	.502 "	1.4391

Gramme-equivalent per litre.	Ionization Coefficient at 0° C.	Equivalent Depression.	Gramme-equivalent per litre.	Ionization Coefficient at 0 °C.	Equivalent Depression.
H_3PO_4 (Loomis.)			H_3PO_4 (Jones).		
.03	.614 i. D.	0.94	.003279	.881 i. D.	1.1894
.06	.513 "	0.893	.009843	.771 "	1.1515
			.019605	.669 "	1.0967
			.027705	.627 "	1.0721
			.03279	.602 "	1.0522

The curves of the diagram are so labelled with the initial letters of observers' names, (Ab for Abegg), as to show both the depression observations, on which they are based, and the ionization coefficients used in plotting them. Thus the inscription KCl (J—W), means that Jones' depressions and Whetham's coefficients were used; H_2SO_2 (J L B—B), that the curve is a mean curve based, mainly at least, on depression observations by Jones, Loomis, and Barnes, and plotted with Barnes' coefficients. The limits of concentration for the curves, are indicated also, in gramme-equivalents per litre.

Some of the curves are entered on an inset, drawn on four times the scale of the main diagram.

In interpreting the curves, we must not only bear in mind what has been said above about the probable accuracy of the ionization coefficients, but must in addition note the tendency exhibited by the curves of the various observers, as dilution increases, to run off at great dilution in directions characteristic of the observers, to the left or right relatively to the course pursued by them at moderate dilution. Thus Abegg's curves (see NaCl, KCl, K_2SO_4), and Jones's (see NaCl, KCl, NH_4Cl, HCl) run off to the right. So do Arrhenius's in a marked manner. Raoult's tendency is also to the right, (see NaCl; his K_2SO_4, not plotted, shows it also; his most dilute KCl observation, he himself clearly regards as accidentally out.) On the other hand, Loomis's curves (see HCl, KNO_3, NH_4Cl, $BaCl_2$) go to the left.

So do Ponsot's, and probably Wildermann's (not plotted), and I gather from Ponsot's diagrams of Pickering's observations, to which I have not access, that Pickering's also have the leftward tendency. Archibald's and Barnes' curves show less tendency to diverge than those of any other observers. And although this may be partially, it is not wholly, due to their having worked at moderate dilutions only. For in several cases, pointed out below, the curves of other observers start on a divergent course within their limit of dilution. But the fact that their curves usually agree with Loomis's, would lead one to suspect them of a leftward tendency.

The divergence, as shown on the diagram, is most marked in the case of highly dissociated electrolytes (NaCl, HCl, etc.) in which, at great dilution, the rate of increase of ionization with dilution is small, the curves being crushed up, therefore, into a small space. But it is obvious also, in the K_2SO_4 curves (especially Abegg's) and the $BaCl_2$ curves (including Ponsot's, not shown). And although for $MgSO_4$ and H_3PO_4, whose ionization increases rapidly with dilution, the single curves do not reveal it, the relative positions of the two curves in each case are what they might be expected to be, if they were tending unduly, Jones's to the right, and Loomis's to the left.

This tendency is explicable at once, when we reflect that as it is equivalent depression that is plotted, the errors of the observations are brought into greater and greater prominence as dilution increases. According, therefore, as the characteristic error of an observer's method of measuring total depression is positive or negative, will his curves of equivalent depression diverge at great dilution to the right or left of their true course. And they must diverge even if the error is very small.

The equivalent depression curves of single observers are therefore open to grave suspicion at high dilutions; and since one can never be sure that the errors of different methods will even approximately neutralise one another, mean curves are, at high

dilution, not much more trustworthy than their components.* It is much safer, therefore, to base conclusions as to depression constant on moderate dilution curves, although the conclusions they admit of may not be so exact as we might wish.

Discussion of the Curves.

Electrolytes such as NaCl, HNO_3, KOH, have 1 equivalent in the single molecule, and 2 ions. If, therefore, they exist in solution in single molecules, their curves should be normal 1—2 curves. If the molecules are all double or triple, the curves should be 2—4 or 3—6 curves, provided the association does not involve change in the mode of ionization. If it does, they may be 2—2, or 3—4, 3—3, 3—2 curves respectively, according to the change that may occur. If the molecules are single at extreme dilution, but become double or triple as dilution diminishes, the curves should start as 1—2 curves, and undergo the appropriate transformation.

The electrolyte for which we have the most complete and trustworthy data, is KCl. The LB—B curve is based on two series of observations in close agreement and by a method exhibiting less divergence than the others. Jones's runs a little to the right of it; Abegg's a little to the left. Both Raoult's and Wildermann's cross it, the latter being somewhat steeper, the former less steep. Ponsot's

* It follows that it is inadmissible to proceed as Raoult has done in determining depression constants, (*loc. cit.* p. 658), viz., by selecting high dilution curves which are in agreement, and applying extrapolation to a mean curve derived from them; for such procedure may mean the selection of observations made by methods which have characteristic errors of the same sign. In fact, a mean curve based on observations which agree well at low dilution, but disagree markedly at high dilution, would be likely to give a better result, as more probably combining observations with small characteristic errors of opposite sign. Raoult's procedure is open to other objections. For (1) his curves of equivalent depression against total depression, make series of observations appear to be in greater disagreement than they really are, and are thus not helpful in making a judicious selection of observations to be used; and (2.) extrapolation of such curves not only gives a result affected by the average of the characteristic errors of the observations used, but also neglects the possibility, in some cases the probability, that owing to change in association and mode of ionization, the law of the change of curvature may be very different beyond the limits of observation, from what it is within these limits.

coincides with the lower part, but in the upper part diverges to the left. In form the curve is thus probably trustworthy. But being plotted with Barnes' coefficients it may be too high or too low. The R—W and J—W curves (see inset) are not open to this suspicion, but at the dilutions to which even their lower and more trustworthy parts apply, they may have begun to diverge unduly rightwards. If the L B—B curve (see inset) be raised about 2.5 per cent., as is shown to be necessary by a comparison of Whetham's and Barnes' coefficients, it comes into a position to the left of the R—W and J—W curves, the usual relative position of the curves of these observers. Loomis's own curve for somewhat greater dilutions than those of the L B—B curve, when plotted with Whetham's coefficients, coincides very nearly with the boundary line of the inset; Wildermann's is a little to the left of Loomis's, and somewhat steeper. Both exhibit a slight rightward bending, as do all the others.

It would be difficult to draw a mean curve with any confidence; but any such curve would run about midway between the 1—2 and 2—4 (1.85) lines, would have a slight rightward bending at its upper end, and if produced with diminishing curvature, would run out to a point a little to the right of the 1—2 (1.85) intersection.

If this intersection were the starting point of the curve, and if there were no association, the curve should lie wholly to the right of the 1—2 (1.85) line. If, as dilution diminished, sufficient doubling of molecules with unchanged mode of ionization should occur, the curve, after first bending away from that line to the right, would change its curvature, bend towards the line and cross it, and then run towards, and finally away from, the 2—4 line, as the mean curve appears to do.

As the 2—2 line is far to the left, the mean curve might be accounted for also, on the assumption of a very slight formation of double molecules dissociating into two ions; and a slight formation of such molecules would probably involve no greater variation of the migration numbers with concentration than has been observed.

If the 1—2 (1.86) intersection, were assumed as the starting point of the curve, the mean curve would cut the 2—4 (1.86) line. If, therefore, association in molecules with unchanged mode of ionization were assumed, some formation of triple molecules would be indicated, and if the associated molecules were assumed to dissociate into two free ions, a greater extent of such association would be indicated. Thus, with this starting point, less probable assumptions as to association must be made, to account for the observations.

If the 1—2 (1.84) or even the 1—2 (1.845) intersection were taken as the starting point, the curve must bend considerably to the left before running out,—of which bending none of the experimental curves give any indication whatever.

The most probable conclusion, then, that we can draw from the observations, is that the depression constant is 1.85, with a limit of error of .01, or perhaps .005, that the electrolyte has single molecules at great dilution, and that as dilution diminishes, either double molecules with unchanged mode of ionization form to a considerable extent, or double molecules dissociating into two ions, to a small extent.

Loomis's and Barnes' observations, on which the NaCl (L B—B) curve is based, are also in close agreement; but as Loomis's curve for slightly greater dilution bends slightly to the right, the upper part of the L B—B curve should probably have greater curvature. Jones' curve for moderately dilute solutions runs a little to the left of it, and at higher dilutions diverges markedly to the right, as separately shown. Abegg's observations are on both sides of it, but at higher dilutions his curve also goes to the right. Raoult's touches it, but goes off to the right. Arrhenius's is considerably to the right, and goes widely rightward at greater dilutions. Ponsot's is a little to the left. As the L B—B curve is plotted with Barnes' coefficients, it is probably too low. If it be raised about as much as was found necessary in the case of the KCl curve, it will lie along the 1—2 line, or a little above or below it, with its upper end, as drawn, so directed, as to run out probably at a point nearer the

1—2 (1.85) intersection, than either the 1—2 (1.83) or the 1—2 (1.87) intersection. Thus the defective data as to ionization prevent our drawing a more definite conclusion than that the association indicated, if any, is less than in the case of KCl, and that the depression constant is 1.85, with a limit of error of perhaps .02.

The HCl curve is interesting as exhibiting a point of minimum equivalent depression. The observations on which the L B—B curve is based, are in good agreement. Jones' curve almost coincides with it in the lower part, but goes off to the right in the upper part and at higher dilutions, as shown separately. Loomis's curve at higher dilutions (also separately shown) goes to the left, but in a less marked manner. As drawn, the upper part of the mean curve lies between the 1—2 and 2—4 (1.85) lines, and it is running out to a point a little beyond the 1—2 (1.86) intersection (see inset). But as it is plotted with Barnes' co-efficients it is perhaps too low. If raised 1 or 2 per cent. it would appear to run out at some point between the 1—2 (1.84) and 1—2 (1.86) intersections. The data are of course very defective; but they are consistent with a depression constant of about 1.85, and they seem to indicate a greater extent of association than in the case of KCl.

The L—D and J—D curves for NH_4Cl are not in agreement, having the usual relative position of Loomis's and Jones' curves. A mean curve based on their lower parts would be slightly to the left of the 1—2 (1.85) line, and directed to a point considerably to the right of the 1—2 (1.86) intersection. It might thus indicate anything between a high value of the depression constant accompanied by very considerable association of molecules, and a constant of about 1.85, with no association in dilute solutions, and only a slowly increasing association in stronger solutions.

The HNO_3 curve (see inset) is a mean curve based on Loomis's and Jones's. Both are beyond the bounds of the inset, the former to the left, the latter to the right. Neither this curve nor that of KNO_3 is sufficiently trustworthy to warrant any

close inspection, but both are clearly consistent with the 1.85 value of the depression constant. If the leftward bending of the KNO_3 curve in its lower part were actual, as well as the position of the curve, the formation of triple molecules might be indicated. But being a Loomis curve, it is open to the suspicion of being as a whole, too far to the left; and it is plotted with doubtful coefficients.

The KOH curves, Loomis's on the main diagram and Jones's on the inset, are useful only to illustrate the difficulty of making concordant observations by different methods. As usual, Loomis's is to the left, and Jones's to the right.

Electrolytes such as $BaCl_2$, H_2SO_4, Na_2CO_3, have 2 equivalents in the single molecule, which may dissociate into 3 or into 2 ions. If there is no association, they will therefore have 2—3 or 2—2 curves, according to the mode of ionization. If there is complete doubling of molecules, the curves will be 4—6 or 4—4 curves, provided the doubling does not involve change in mode of ionization. Otherwise they might be 4—5, 4—3 or 4—2 curves. (The corresponding tangent lines are so far to the left of the experimental curves that they are not entered on the diagram.) If the molecules are associated in threes, the curves will be 6—9 or 6—6 curves, with the above proviso.

Both Loomis's and Jones' curves for $BaCl_2$ are shown on the diagram, plotted with Whetham's coefficients (rough extrapolated values, however, in the case of the former). Ponsot's curve agrees very closely with Loomis's. Bearing in mind the rightward and leftward tendencies of Jones's and Loomis's curves, respectively, we may conclude from the curves of the diagram that the actual curve runs down to the right of the 2—3 line, bending away from it to the right, and that it would intersect the $a=1$ line at a point between the 2—3 (1.85) and 2—3 (1.87) intersections, probably nearer the former than the latter. The curve is thus, so far as we can judge, a normal 2—3 (1.85 ± .01) curve, running, however, very close to the 2—3 line. The diagram, therefore, indicates that $BaCl_2$ exists in solution in single molecules, dissociating into 3 ions, at least for the most part, and that it has a depression constant nearer 1.85 than 1.87.

The H_2SO_4 (J—W) curve for high dilutions, being a Jones curve, is probably too far to the right, and being plotted with Whetham's coefficients, is probably too high. Wildermann's curve for high dilutions runs parallel to it, considerably to the left. The J L B—B curve, for lower dilutions, is very nearly coincident with Barnes' curve, and in its lower part with Jones's and Loomis's as well. But in the upper part, Jones' curve goes off markedly to the right, and Loomis's markedly to the left. Wildermann's is slightly to the left at the lower end, and diverges somewhat leftwards in the upper part. Ponsot's runs nearly parallel to it, somewhat to the left, and diverging to the left at higher dilutions. The J L.B—B curve is thus trustworthy as to form; but being plotted with Barnes' coefficients, it is probably too low. The actual curve would thus appear to cross the 2—3 (1.85) line not far from its starting point, bend towards the 4—6 line, and run down below that line, finally bending slightly towards it. Its course is therefore what it would be if it started as a 2—3 curve, for $k = 1.85$ or thereabout, changed its curvature at a somewhat early stage, and tended to be transformed slowly into either a double molecule curve or a 2—2 curve, or perhaps both. The diagram would therefore indicate that at extreme dilution H_2SO_4 exists in solution in single molecules, dissociating into three ions, that at an early stage and in a somewhat marked manner, either doubling of molecules sets in, or partial dissociation into two ions, or perhaps both, that the change increases slowly and steadily as dilution diminishes, and that at a concentration of about 0.6, if the coefficients at this concentration are to be trusted, the change is increasing in rate; also that the depression constant may quite readily be about 1.85.

The K_2SO_4 (L J A—A) curve, is based on series of observations which in the main are in good agreement. It very nearly coincides with the Loomis and Archibald curves, and Ponsot's runs down slightly to the left. In its lower part it coincides with the Jones curve, but in its upper part the Jones curve, which is separately represented for great dilutions, runs off to the right. Abegg's curve for higher dilutions runs even more

markedly to the right, although it is farther to the left at its lower end. Arrhenius's is considerably to the right, and diverges widely rightwards. The Na_2SO_4 (L A—A) curve is also almost coincident with both the Loomis and the Archibald curves. Both Raoult's and Arrhenius's are considerably to the right, and diverge slowly rightwards. Such of these curves as are entered on the diagram, being plotted with Archibald's coefficients, are probably somewhat too high or too low, as the case may be. Those for great dilutions are too discordant to admit of discussion. The mean curves for both salts have the same general form, and run down, as drawn, a little below the 2—3 line. Their upper ends are so directed as to suggest their running out at the 2—3 (1.85) intersection, or thereabout. At their lower ends they turn sharply to the left and cross the 2—3 line, going towards the region of the double molecule curves, or of the 2—2 curve. The turns are too sharp, and the 4—6 and 6—9 lines too near, to make their transformation into double or triple molecule curves, with unchanged ionization, probable. The diagram suggests rather their transformation into 4—5, 4, or 2 or 2—2 curves. If this be accepted, it means that at extreme dilution these sulphates exist in solution in single molecules, dissociating into three ions, that partial dissociation into two ions or doubling of molecules sets in, apparently at an early stage, but increases more slowly than in the case of H_2SO_4, until the dilution has been considerably diminished, when it undergoes a rapid increase. A close determination of the depression constant cannot be made; but even if the curves have to be either raised or lowered a little, and if, Loomis's tendency being leftward, their upper parts have to be shifted somewhat to the right, they will be consistent with its being about 1.85.

The Na_2CO_3 curves are too discordant to form a basis for discussion. But either Loomis's curve or a mean curve, or even Jones's curve itself, is quite consistent with a depression constant of about 1.85; and both curves indicate the occurrence of rapid association or of rapid change of ionization after considerable diminution of dilution. The fact that

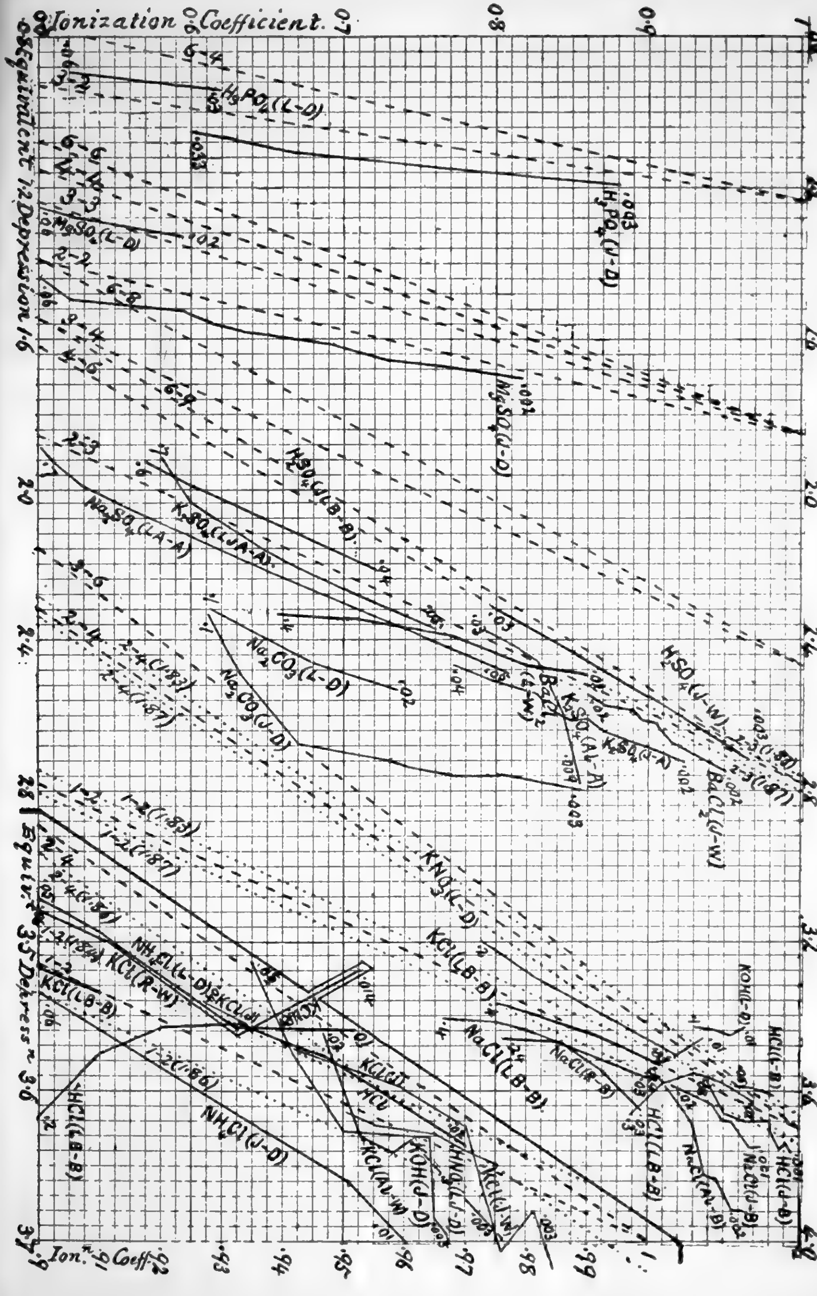
Loomis's curves bend towards the left, suggests that the actual curve after starting at the 2—3 intersection, may bend considerably to the right before association or change of mode of ionization has advanced sufficiently to change the direction of its curvature.

An electrolyte such as $MgSO_4$, according as it may exist in solution in single, double or triple molecules, and according to its mode of ionization in associated molecules, may have a 2—2, 4—4 or 2, or 6—6, 4, 3 or 2 curve. Jones' curve lies to the right of the 2—2 (1.85) line, bending towards it, and may quite readily be a 2—2 (1.85) curve, changing to a 4—4 or 4—2 curve. Loomis's lies between the 2—2 and 4—4 lines. A mean curve would already, at a concentration .02, have crossed the 2—2 line. The data, such as they are, are consistent with the depression constant having a value of about 1.85, and would indicate single molecules in dilute solutions, doubling of molecules at a very early stage, and a steady increase in association throughout.

According as H_3PO_4, if it exist in solution in single molecules, may dissociate into 4, 3 or 2 ions, will it have a 3—4, 3—3, or 3—2 curve. If it have double molecules, its curve may be a 6—8, 6—7, etc., to 6—2 curve, according to the mode of ionization. Jones' curve runs down to the right of the 3—2 (1.85) line, bending towards the line. Loomis's lies between the 3—2 and 6—4 lines. A mean curve would be just to the right of the 3—2 line, and might readily run out at the 3—2 (1.85) intersection. This would indicate single molecules in dilute solutions dissociating into two ions, an early occurrence of doubling of molecules, and steady increase in the extent of association as dilution diminished, the double molecules formed dissociating into 4, 3, or 2 ions, but not into more. Although the coefficients with which the curve is plotted are doubtful, the curve is so nearly parallel to the axis of ionization coefficients, that even a considerable error in their values would not affect the above conclusions.

General Conclusions.

Although the observations on which the above discussion is based are defective, and the particular conclusions drawn are consequently tentative, I think it may be held with some confidence (1) that the curves of equivalent depression against ionization coefficient, have positions, forms, and slopes, such as they might be expected to have, on reasonable assumptions as to mode of ionization and constitution in solution, according to the Van 't Hoff-Arrhenius theory of the depression of the freezing-point in solutions of electrolytes, (2) that for all the electrolytes examined, they are consistent with the depression constant having a common value of about 1.85, and that in the case of the electrolyte for which we have the best data, the curve is not consistent with a greater limit of error in this value than about .01, unless improbable assumptions are made with respect to the constitution of the electrolyte in solution, and (3) that the diagram enables us to reach in some cases, conclusions of considerable probability with respect to the constitution of the electrolyte in solution, and its mode of ionization.


Ionization Coefficient.
0.6
0.7
0.8
0.9
1.0
Equivalent 1.2 Depression 1.6
2.0
2.4
2.8
3.2
3.6
Equiv.ts 3.5 Depress.n 3.6
Ion.n Coeff. .91
.92
.93
.94
.95
.96
.97
.98
.99
1.
H3PO4 (L-D)
H3PO4 (J-D)
MgSO4 (L-D)
MgSO4 (J-D)
H2SO4 (J.L.B-B)
K2SO4 (L.J.A-A)
Na2SO4 (L.A-A)
Na2CO3 (L-D)
Na2CO3 (J-D)
H2SO4 (J-W)
K2SO4 (J-A)
BaCl2 (J-W)
KNO3 (L-D)
KCl (L.B-B)
NaCl (L.B-B)
NaCl (R-B)
HCl (L.B-B)
NH4Cl (L-D) & KCl (J)
KCl (R-W)
NH4Cl (J-D)
KOH (J-D)
HNO3 (L-D)
KCl (J-W)
KCl (Ar-W)
NaCl (J-B)
HCl (J-B)
KOH (L-D)

VIII.—Geological Nomenclature in Nova Scotia.—By Hugh Fletcher, Esq., B. A., *of the Geological Survey of Canada.*

(Communicated on the 14th May, 1900.)

The Devonian.

In the summer of 1876, a great series of metamorphic rocks, cut by masses of granite and trap, was separated in Cape Breton from the overlying Carboniferous conglomerate made up of their detritus. These rocks were then traced from Loch Lomond to St. Peters, through Isle Madame and into Guysboro and Antigonish counties, as recorded in the reports of the Geological Survey between 1877 and 1881.

Localities were described at which the Carboniferous, comparatively unaltered, comes in contact with and contains pebbles of these metamorphic rocks; several sections indicating a thickness of at least 10,000 feet were given in detail and mention was made of carbonized plants, fish remains, ostracods and other fossils found in many of the beds, the plants including forms like Psilophyton, a characteristic Devonian genus.

Above them lies a formation, several thousands of feet in thickness, containing marine fossils of the Carboniferous Limestone series of England and characterized everywhere from Newfoundland to the western boundary of New Brunswick, a distance of 450 miles, by the occurrence of thick beds of gypsum; while at their base lie about 3,000 feet of limestones and other beds of marine origin, shown by Dr. Honeyman, in one of the finest pieces of combined stratigraphical and palæontological geology yet done in Nova Scotia, to range at Arasaig from Medina to Lower Helderberg.

Rocks in this position, precisely similar in lithological character, had been called Devonian in New Brunswick, Newfoundland, Gaspé and on Logan's map of the Pictou Coal field, and this name was accordingly applied to them in Cape Breton.

It was subsequently found that the large Pre-carboniferous area, eighteen miles wide at the Strait of Canso and five miles in width at Lochaber, thirty-five miles to the south-west, instead of being Silurian as claimed by Sir William Dawson, contains only these plant-bearing Devonian strata which are divisible into three groups corresponding closely with those into which the Devonian rocks of New Brunswick had already been subdivided. They extend from Lochaber along the East River of St. Mary's and the East River of Pictou to strike the Intercolonial railway near Glengarry, form the high land south of Truro and pass unconformably beneath the Carboniferous of Stewiacke River; and a small area is found at MacAra Brook, from which come the fish remains and Pterygotus subsequently described by A. Smith Woodward as homotaxial with the upper Silurian or lower Devonian of England.

As this grouping affected also rocks referred by Sir William Dawson * on the evidence of their fossil plants "to the lower part of the coal formation or Millstone Grit" and even higher, it was naturally called in question; and in 1885 Mr. T. C. Weston was sent to Nova Scotia, assisted by Mr. J. A. Robert, to collect fossils between Riversdale and the Strait of Canso. They found everywhere *Lepidodendron corrugatum, Stigmaria ficoides* and *Cyclopteris acadica,* forms supposed to be characteristic of the Horton series; on the East River of St. Mary's plants which resemble rhizomes of *Psilophyton;* and, near Sunnybrae, Cordaites and numerous markings of *Psilophyton* allied to *P. glabrum* and *P. elegans;* at and near Riversdale they obtained *Calamites, Sphenopteris, Anthracomya elongata* and *A. laevis, Lepidodendron corrugatum, Stigmaria ficoides,* ferns and erect trees, characteristic again of the Horton series.

These rocks near Truro and on Cobequid Bay and Minas Basin had in the meantime been recognized by Dr. Ells as probably identical with the Devonian of New Brunswick.

---

* Acadian Geology, pages 485 and 489; Plants of the Lower Carboniferous and Millstone Grit, p. 13.

The Reports of the Geological Survey for 1885 and 1886 were sharply assailed by Sir J. W. Dawson for their disregard of fossils; they were assumed to cast doubt upon the value and accuracy of the work done in Cape Breton. "As to the rocks of the Riversdale section and that at MacKay Head, I have no hesitation in saying that it would be contrary to all analogy, not only in Nova Scotia but everywhere else, that they should be as low as the Horton series. They are unequivocally Millstone Grit and the flora of these sections is so well known that there can scarcely be any mistake respecting it. The opinion advanced by Dr. Ells that the rocks of MacKay Head are like those of Riversdale is quite correct, they being the same series; but the comparison of them with the St. John Devonian is quite unwarrantable, the fossils being quite distinct."

This strong dissent induced Dr. Selwyn in 1892 to visit the region and see for himself the position of these strata. His view of their relations was emphatically expressed in the Summary Report for that year. In the conclusions arrived at by Mr. Fletcher he fully agreed. In 1895, Dr. Selwyn was succeeded as director of the Geological Survey by Dr. G. M. Dawson. Maps of Pictou and Colchester counties were then being engraved. The compilation of Sheets 43 to 48 was completed and that of Sheets 56 to 65, 76, 83, 100 and 101 well advanced. In the same year Dr. Ami was sent to Nova Scotia to obtain palæontological evidence of the age of the rocks in question; in the following seasons he was accompanied by the director, and in one season by Dr. Ells.

But in 1898 "certain points connected with the geological structure of that region remained still critical," although it was hoped that the special investigations of that year might render it possible to complete the information for several of the above sheets, which in that event would be promptly issued. At this time, Dr. Ami was protesting against the publication of a report in which he was represented as advocating the Carboniferous age of these rocks. On the contrary, he believed the evidence to show "that the strata of Union and Riversdale may be

regarded as equivalent to those in Lancaster township, New Brunswick, described and held to be of Devonian age," adding that several typical Horton fossils, such as *Lepidodendron corrugatum* and *Cyclopteris acadica* are common to the Riversdale and Union rocks and to the Devonian of New Brunswick.

In the following year, however, he states that so far as the faunas are concerned they clearly indicate a Carboniferous facies for the New Brunswick Devonian, the rocks of Harrington River, Parrsboro, Riversdale, Union and Horton Bluff. The only proof adduced for this radical change, and the addition of 15,000 feet of strata beneath the Limestone to the already enormously developed Carboniferous of Nova Scotia, is that of certain fossils, assumed to have a definite range, in regard to some of which he is surely mistaken. For "the protolimuloid crustacean, usually referred to the Carboniferous system" is on the contrary* also found associated with such characteristic Lower Devonian forms as *Pterygotus, Coccosteus, Pterichthys* and *Glyptolepis*; *Estheria* is not "all the world over recognized as Carboniferous" any more than *Pterinea* is peculiar to the Devonian; *Leaia* occurs in Pennsylvania in rocks regarded by most geologists as Devonian; and Professor Marsh has described, from the Devonian, amphibians as highly developed as the *Dendrerpeton* found by Sir William Logan at Horton Bluff in 1841 and by Dr. Ami, at Parrsboro in 1898, the affinities of which the latter regards as Permian.

Collections of fossil plants from these rocks in Nova Scotia and New Brunswick were examined by Mr. David White of the United States Geological Survey in 1898, and by Mr. R. Kidston of Stirling, Scotland, in 1899, who came to almost the same conclusions on perfectly independent grounds. Their views are given at length by Dr. Whiteaves in his "Address on the Devonian System in Canada," and may be thus summarized: (1) The Horton series is nearly contemporaneous with the Pocono formation of the eastern United States and the lower

* Ottawa Naturalist for January, 1900, Vol. VIII, No. 10, p. 256.

Carboniferous of England. (2) The Riversdale and Harrington River series are assuredly newer than the Horton and have a most pronounced Upper Carboniferous facies. (3) The plant-bearing beds near St. John, N. B. are not Middle Devonian but Carboniferous and are the exact equivalents of the Riversdale series.

Dr. Whiteaves adds: "Our knowledge of the organic remains of the Devonian of Nova Scotia is still in its infancy, and it would seem that the plant-bearing beds near St. John, N. B., which have so long been regarded as Devonian, may possibly be Carboniferous."

Admitting apparently that "a classification by faunas alone is one-sided and that the physical history of the strata should also be considered," Dr. Ami, in 1899, set aside the authority of the palæontologists mentioned above and accepted the order of superposition* given by "the two geologists on the Canadian Survey staff, who have studied the question from a stratigraphical and lithological point of view," but, as a sort of compromise, for their name Devonian he substituted "Eo-Carboniferous," just as he had previously employed the word "Eo-Devonian" for the so-called Lower Oriskany of Nictaux. This stratigraphical sequence has indeed been admitted by all geologists who have examined it in the field. Richard Brown, Campbell, Gesner, Lyell, Honeyman, Logan, Poole, Ells, Fletcher, Selwyn and others in Nova Scotia; Gesner, Hartt, Matthew, Bailey and Ells in New Brunswick; Murray in Newfoundland; Ells and Whiteaves in Gaspé—all place these rocks beneath the Carboniferous Limestone, near the debatable line between Carboniferous and Devonian, in many indisputable sections where no thrust-faults, outliers, overturned fossil trees or other agency of theoretical biologists are available to make part Devonian, part Coal Measures.

It becomes, then, a question of the transference across this line not of a few feet of strata but of a system of 10,000 to 15,000 feet of beds cut off from a marine formation both above

* Ottawa Naturalist, Vol. XIII, No. 9, p. 207.

and below by great unconformities and intrusions of granitic rocks. The only evidence brought against the name Devonian is that of certain fossils assumed to have a definite range in geological time. Were such a means of classification possible in the present state of our knowledge, and we were to understand that, for example, rocks must not be called Devonian above the horizon of the appearance of amphibians, or Silurian above that of fishes, such a classification would be quite satisfactory. Palæontology is not, however, one of the mathematical or exact sciences, but has its limitations even in the countries in which it has been most diligently studied; consequently, uncertainty exists both in Europe and America regarding the proper limits of this and other formations. We have heard, for example, the work of the Second Geological Survey of Pennsylvania, a most important and thorough industrial investigation, described as conducted on the plan that correlations can best be made by lithological means. "Frequently one meets with expressions of lack of confidence in the evidence offered by fossils." And in a recent report on the Devonian and Carboniferous* "the whole subject of the value of fossil plants as means of correlation" is said to be "under consideration."

It is only necessary to read this report to realize the difficulty met with in attempting to group these rocks by their fossils in Pennsylvania, Ohio, Virginia, Illinois, Michigan and other states†—a difficulty well stated in a report of the American committee of the International Congress of Geologists‡ as follows: (1) "Shall we include the Catskill rocks (and, when no marine faunas occur, up to the base of the Olean conglomerate and equivalents) in the Devonian? (2) Shall the Chemung marine fauna be taken as the uppermost fauna of the Devonian? Or shall a part or the whole of the marine faunas between the middle Devonian and the conglomerate which introduces the Coal Measures be called Devonian? If an arbitrary line is to

---

* Bulletin of the U. S. Geol. Survey, No. 80, pp. 123, 208 and 228.

† Cf. also "Science" for 26th Jan. 1900, p. 140.

‡ Rep. Geol. Congress, 1888, A. pp. 102, 144; B. pp. 141, 153, 154, 156.

be drawn faunally it should be between the Chemung and the Waverley. . . . . . . The difficulties are not less serious in England, and the Pilton and Baggy beds hold faunas which it is as difficult to settle on the Devonian or Carboniferous side as it has been with the Waverley, Kinderhook or Marshall." Professor J. S. Newberry then proposes a classification in which he includes in the Carboniferous system all strata from the Permian to the Chemung, both inclusive; whereas Professor Hall adopts the first alternative suggested above and restricts the term Catskill group to the beds known as X and XI of the Pennsylvania survey (Pocono and Mauch Chunk); and others speak of the latter as distinct from and overlying the Catskill. Adopting Professor Hall's grouping it would seem that the Mauch Chunk and Pocono may represent respectively the Union and Riversdale series of the Nova Scotian Devonian; and that, unless the littoral and estuarine sediments of Pennsylvania represent the pelagic rocks of the east, there must be a great unconformity by which the gypsiferous formation, traced, as above stated, from Newfoundland to the Aroostook, is lost. It has been found that in working up from the lower Palæozoic, the fossils seem to carry the Catskill to XI of the Pennsylvania classification, in working downward from the upper Palæozoic, the fossils seem to carry the Permian to VIII (Venango).

The International Congress proposes to place the upper limit of the Devonian at the base of the Carboniferous Limestone and to include in the former the Catskill and the so-called Lower Carboniferous or Tweedian group of Scotland. The Tweedian has been also correlated with the Condroz beds of Belgium, from which one of the subdivisions of the Devonian (Condrusian) in the classification of the Congress takes its name.

The annexed tabular view of various classifications proposed for these rocks will show at once their radical inconsistency and the indefinite range of the fossils:—

1 Canadian Geological Survey.	2 Ells & Fletcher.	3 Dawson in New Brunsw'k.	4 Dawson in Nova Scotia.
Carboniferous System.			
Permian.	Permian, or Upper Carboniferous.	Upper Carboniferous.	
Coal Measures.	Coal Measures.	Coal Measures.	Union or Salmon River.
Millstone Grit.	Millstone Grit.	Millstone Grit.	Riversdale.
Carboniferous Limestone.	Carboniferous Limestone.	Windsor Series.	Windsor Series (Upper Carboniferous of Schuchert.)
Carboniferous Conglomerate.	Carboniferous Conglomerate.	Horton Series or *Albert Shales.	Horton Tweedian of Scotland.‡
Devonian System.			
Catskill.	Union, including rocks of MacAra Brook, Lochaber and Economy.	Perry.	
Chemung.		Mispec.	Logan's Devonian of Middle River of Pictou. Rocks of Brookfield.
Hamilton.	Riversdale, Harrington River (4000 ft). MacKay Head and Horton.†	Cordaite Shales Dadoxylon Sandstone.	
Corniferous.	Basal Conglomerate.	Bloomsbury.	
Oriskany.			
Silurian System.		Dr. G. F. Matthew suggests placing the Cordaite Shales in the Silurian.	

* An unconformable series beneath the lower carboniferous limestone and conglomerate.

† The relation of the Horton to the beds immediately overlying the Silurian has not yet been worked out.

5 R. Kidston.	6 David White.	7 Pennsylvania.	8 James Hall.	9 J.S. Newberry.
Union ?				Permian.
Riversdale, Harrington River, and Cordaite Shales (St. John Devonian).	Union			Coal Measures.
	Riversdale and Cordaite Shales (Devonian of St. John, N. B.)	Pottsville XII (Olean.)		Millstone Grit.
		Mauch Chunk XI.		Carboniferous Limestone.
Horton — (Lower Carboniferous of England).‡	Horton (Pocono of Pensylvania, Waverly. Newer than Kiltorcan).	Pocono X (White Catskill of Lesley).		Waverley.
		Catskill IX.	Mauch Chunk XI. Pocono X.	Catskill.
		Chemung VIII (Venango).		Chemung.
				Devonian System. Hamilton.
				Corniferous.
				Oriskany.
				Silurian System.

‡ Referred by the International Congress of Geologists to the Devonian (Condrusian).

Only the knowledge that palæontologists sometimes "give more consideration to the results of theoretic biologic studies than to the already established stratigraphic succession of the faunas" can explain the foregoing table, which offers the alternative of correlating with the Nova Scotian productive coal measures, lying thousands of feet above the Riversdale, either the Coal Measures of England or the Cretaceous coal-bearing rocks of the Pacific coast.

The Horton cannot be at the same time above and below and on the same horizon as the Riversdale; and Dr. Ami has perhaps acted wisely in omitting it from his classification, its prominence in the others being due to its being easily accessible and first examined. At Horton Bluff it contains only 287 feet of strata well exposed on one side of a syncline, and 459 feet, not so well exposed, on the other; whereas the section at Harrington River shows nearly 4000 feet of black and gray beds; that near Union station 6468 feet of red beds of the upper * group alone (of which 684 feet, containing fish remains throughout, were remeasured at MacAra Brook); while a great thickness of the lower gray and black beds is exposed along the railway from Riversdale to West River and in every brook flowing south from the Cobequid Hills, these exposures being sometimes almost continuous for several miles, as recorded in the reports of the Geological Survey.

It will be readily understood that fossils thus studied and applied, having fixed no definite horizon higher than the Lower Helderberg, have hindered not helped in mapping the comparatively simple geological structure of these formations, while most satisfactory progress has been made by Mr. Fairbault in an investigation of 27,000 feet of more complicated, non-fossiliferous rocks comprising the gold-bearing series of the province.

---

* Geol. Survey Report for 1886, Part P, page 65.

IX.—Notes on a Cape Breton Mineral containing Tungsten, and on the Effect of Washing Certain Cape Breton Coals.—By Henry S. Poole, F. G. S., F. R. S. C., *Assoc. Roy. Sch. Mines, etc., Stellarton, N. S.*

(Read April 14th, 1900.)

In the last issue of the Transactions of this Institute there was published a paper read March 13th, 1899, entitled "New Mineral Discoveries in Nova Scotia." The paper made reference to the finding at North East Margaree, C. B., of a mineral containing tungsten and speaks of it as Wolframite with 67.47 per cent. of WO_3, but makes no note of its other constituents. A month later, at a meeting of the Mining Society, Mr. A. C. Ross read a paper on the same mineral, and in the discussion which followed an analysis made by Mr. Mason, the assayer at Halifax, was given by Mr. Missener. This analysis,* of concentrated ore, showed but a trace of iron, and was as follows:—

Tungsten Trioxide	66.32
Silica	6.25
Manganese	12.02
Iron	.12
	84.71

* The following letter from Mr. Mason gives additional information about this analysis:—

Halifax, Nova Scotia, April 23rd, 1900.

My dear Mr. Poole:

The analysis was made for commercial purposes, not for scientific ones. However, being of a curious turn of mind I am able to give you some further information, although unfortunately only qualitative, not quantitative. A close inspection of the mineral (I fancy I gave you a sample) will I think reveal that it is composed of Quartz and Hübnerite principally, but there is also a little Scheelite. With regard to the missing 15 per cent., the Manganese is reported as metal. I fancy it exists in the mineral as Mn_3O_4, and if so, that accounts for a difference of about 4.5%. The balance was made up of mixed oxides of Niobium and Tantalum, and also of Lime. Whether the lime all belongs to the scheelite or whether part of it should join the quartz as gangue, I did not determine. I regret that I have mislaid the memo. of the quantities. I did not discover that the mineral also contained Scheelite until I panned some of it, but afterwards clearly detected it in some samples but could not find it in others.

Yours very truly,

F. H. Mason

The absence of iron and the comparatively large amount of Manganese in the composition of this mineral would class it as more nearly allied to Hübnerite than to Wolframite.

In the same paper reference is made to the beneficial effects from washing certain Cape Breton coals, whereby the quantity of Sulphur ordinarily contained in coal as supplied from the slack heaps is greatly reduced, and the resulting Coke is made suitable for Iron smelting. The experience at the Ferrona furnace is spoken of, but as the reference to the operations at that furnace are somewhat incomplete, the following data supplied by the Manager, Mr. J. D. Fraser, will doubtless on comparison prove of interest. A test made in September and October, 1895, with fifty-ton samples from each of the following Mines, gave as follows:—

	Raw Coal.		Washed Coal.	
	Ash.	Sulphur.	Ash.	Sulphur.
Hub.	7.50%	3.24%	4.37%	2.38%
Caledonia ..	15.00 "	3.02 "	7.05 "	2.87 "
Stirling ...	11.09 "	4.23 "	5.50 "	3.12 "
Gowrie	11.55 "	5.26 "	6.01 "	3.15 "

D. Herting, *Chemist.*

A test of 10,000 tons of small coal in December, 1897, and January, 1898, received from the Dominion Coal Company, gave the following average results:—

	Raw Coal.	Washed Coal.
Moisture.	2.10%	1.97%
Volatile Combustible Matter.	31.00 "	33.21 "
Fixed Carbon.	56.83 "	60.00 "
Ash.	10.07 "	4.82 "
Sulphur	2.38 "	1.79 "

Coke made from this washed coal analysed:—

Ash.	9.16%
Volatile Combustible Matter	1.86 "
Fixed Carbon	88.98 "
Sulphur	1.62 "

I. Macfarlan, *Chemist.*

For comparison with the work done in the coal washer, a laboratory test was made. An average sample of the coal was treated in a solution of Calcium Chloride of 1.40 Sp. Gr., the coal of 1.30 Sp. Gr. floated on the solution, and the shale of 2.04 Sp. Gr. sank to the bottom. Thus separated, the coal and shale were thoroughly washed and dried, and severally bore to the unwashed material the following proportion :—

Coal.	81 %
Shale, etc.	90 "

Dried at 212° Fahr. they yielded on analysis :—

	Raw Coal	Washed Coal.	Shale.
Volatile Combustible Matter.	33.06 %	33.79 %	31.43 %
Fixed Carbon	55.93 "	61.33 "	15.33 "
Ash	11.01 "	2.89 "	48.08 "
Sulphur	2.41 "	1.64 "	5.16 "

The same Coal treated in the coal washer yielded :—

	Raw Coal.	Washed Coal.	Shale.
Volatile Combustible Matter.	33.06 %	34.07 %	30.82 %
Fixed Carbon	55.93 "	61.26 "	23.21 "
Ash	11.01 "	4.67 "	41.22 "
Sulphur	2.41 "	1.70 "	4 48 "

On coking, 204 ovens made 683 tons of coke which showed an average composition as follows, after being dried at 212° F. :—

Moisture	0.40	
Volatile Combustible Matter	1.60	
Fixed Carbon	89.82	
Sulphur	1.65	
Silica	3.52	Ash 8.18 %
Metallic iron	1.71	
Alumina	.46	
Manganese	.03	
Lime	.82	
Magnesia	.16	
Phosphorus.	.02	

Available Carbon, 87.02.

X.—Minerals for the Paris Exhibition.—By E Gilpin, Jr., LL. D., F. R. S. C., *Inspector of Mines.*

(Communicated 12th February, 1900.)

The Government of Nova Scotia having decided to assist the Canadian Geological Survey in the preparation of the Canadian Mineral Exhibit at the Paris Exhibition, the work of collection was assigned to the Mines Office. In the process of collection opportunity has been afforded of procuring some interesting information. I do not contemplate giving a detailed account of each mineral locality represented, as that would occupy an undue space in the Transactions, but will confine myself more especially to those exhibits which were accompanied by descriptive matter, analyses, etc. It may be remarked that no trouble has been spared by the Survey to make the mineral exhibit a leading feature of the Canadian representation at Paris, so that all the mining districts will undoubtedly receive a most important and valuable advertisement. It is to be regretted that so many mining men have neglected the opportunity offered of presenting not only their own operations, but also those of their country to the gaze of the world. At no time has there been on the continent of Europe so marked a difficulty in procuring the raw material, and the unworked metals, and there is also a great demand for opportunities for investment of capital. This interest is not confined to the precious metals, but extends to every mineral that can be utilized in the arts. In many cases, the Department, instead of receiving samples from mine owners only too pleased to have their products exhibited, was obliged to send to the quarries, etc., and procure specimens, while the owners showed no interest whatever. Paternalism may be good, but the individual should show an interest in his own welfare.

Coal.

As would be expected the coal fields are well represented. The Springhill coals were shown in their different forms as

presented for consumption. These coals are largely used for steam purposes, especially in locomotives, they are also good coking and domestic coals. In recent communications to the Institute I have given a number of analyses of these coals, showing the increase of their steam values, etc., as they have been followed to the dip.

The Dominion Coal Company exhibited the various forms of round, run of mine, slack, pea, nut coals, etc., required by the trade. This company also presented a column of coal, a section of the Phalen seam, which attains a thickness of nine feet. This column is to stand by a similar one from British Columbia, an illustration of the resources of Canada on the Pacific and on the Atlantic. In my last paper I drew attention to the interesting diminution in ash and sulphur in the Phalen seam as it was followed away from its outcrop. I also gave a summary of the tests of coal made at Glassport, Pa., U. S. A. I now give, as an interesting comparison, the results of similar tests of the Phalen and Hub seams made at the Solway ovens, in Syracuse, New York, U. S. A. Owing to rainy weather the car loads were saturated with moisture. Allowing for the moisture the sample of the Phalen seam weighed 405 tons, and that from the Hub seam weighed 307 tons. There were obtained from these coals respectively 302 tons, 74.68 per cent; and 224.74 tons, 72.37 per cent, of dry coke and breeze.

The Phalen seam yielded 11,012 cubic feet of gas per long ton. Of the gas 55.47 per cent was used under the ovens. The average calorific power of the gas was 571.85 B. T. U. The average illuminating value of the gas, with a fishtail burner was 9.9 candle power, with a Welsbach burner, 54.34 candle power.

The following is the average analysis of the gas:—

Carbon dioxide....	2.7	per cent.	Marsh gas	32.3	per cent.
Illuminants.......	2.9	"	Hydrogen	51.1	"
Oxygen	.13	"	Nitrogen	5.07	"
Carbon monoxide..	5.8	"			
			Total......	100.0	

The Hub seam yielded 10,539 cubic feet of gas per long ton, of which 55.46 per cent was used under the ovens. The average calorific power of the gas was 576.54 B. T. U. The average illuminating value of the gas with a fishtail burner was 9.8 candle power, with a Welsbach burner 54. candle power.

The average analysis of the gas was as follows :—

Carbon dioxide	3.1	per cent.	Hydrogen	50.7	per cent.
Illuminants	2.7	"	Marsh gas	30.9	"
Oxygen	.2	"	Nitrogen	5.0	"
Carbon monoxide	7.4	"			
			Total	100.0	

The Phalen seam yielded per ton 32.91 lbs. of ammonium sulphate, and the yield from the Hub seam was 32.24 lbs. In commercial estimates a deduction of from 5 to 10 per cent should be made for loss of ammonia during the process of concentration.

The Phalen seam yielded per ton 12.89 gals. of tar, 128.9 lbs., and the Hub seam yielded 13.89 gals. of tar, 138 9 lbs. The Phalen seam yielded .103, and the Hub seam .111 gals. of benzole.

In considering the illuminating power and composition of the gases given above it must be remembered that they are averages. It was pointed out in my last paper that the gas obtained from the first portion of the period of coking is much higher in illuminating power, etc., than that given off during the latter portion of the period of coking.

The General Mining Association.—This company has a large number of valuable coal seams, but has hitherto confined its operations to one, known as the Sydney Main Seam. This seam has been worked for over one hundred years, and still remains one of the most valuable assets of the Province. The average thickness of the seam is five feet two inches. The annual output 271,000 tons. The portion of the seam now being worked is entirely under the Atlantic Ocean, the samples exhibited being taken from a point 2,200 yards from the nearest land, and at a depth of 1,000 feet below the bottom of the ocean.

The following analyses made at different periods will show the general uniformity of the seam :

(1871.) Analysis by Dr. How.

Moisture	3.04	Average Coke	70.30
Volatile Combust. Matter	31.14	Theoretical Evaporative power	9.06 lbs.
Fixed Carbon	61.50	Sulphur	1.24
Ash	4.32	Specific Gravity	1.30
	100.00		

(1890.) Analysis by the Writer.

	Slow Coking.	Fast Coking.
Moisture	.420	.420
Volatile Combustible Matter	34.962	37.110
Fixed Carbon	59.993	57.845
Ash	4.625	4.625
	100.000	100.000
Sulphur	.95	.95

(1891.) Average Samples from Five Sections of the Mine.

Moisture	1.536	Fixed Carbon	57.008
Volatile Combustible Matter	36.372	Ash	5.084
		Sulphur	1.894

Of the underlying seams in the North Sydney district, not much can yet be said. The General Mining Association has recently proved them by a shaft to the fourth seam. These seams are of good quality, and from three to four feet thick. I append an analysis of the third seam, made a few years ago, from samples taken from the openings of the North Sydney Mining Company, along its outcrop :—

Moisture	2.06	Ash	7.46
Volatile Combustible Matter	30.16		100.00
Fixed Carbon	60.32	Sulphur	.84

These seams are now receiving attention at the hands of the Sydney Coal Company, and, although thinner than the main seam, will undoubtedly in the near future prove valuable from their uniformity and proximity to deep water.

The coals of Pictou County are represented by samples from the mines of the Acadia Coal Company. These deposits have long been worked. Samples of coal are also shown from the Chignecto, Joggins and Springhill Colleries. Interesting analyses, etc., of the seams found at the last-named district have been furnished by me in late numbers of the Transactions of the Institute.

Manganese.

At present the production of manganese is at a low ebb in this province. For many years the Tenny Cape Mines had a world-wide reputation for the production of small amounts of extremely pure ore. For some time past little ore has been mined. It is not doubted that the resources of the district are exhausted; but the researches of the chemist have pointed out methods for the production of pure manganese oxide as a by product, which have lessened the demand for a native ore almost chemically pure. How ever the demand for manganese for steel making purposes has again offered a market for manganese ores, high in grade, and phosphorus free. Attention is now being directed to the ores of this district, and with modern appliances for prospecting and mining it is anticipated that Tenny Cape will again become a producer. The samples collected exhibit well the celebrated crystalline pyrolusite characterising the district.

The following analysis will serve to show the character of the ores of this district, which occur in lower carboniferous limestones:—

	I.	II.
Moisture	1.66	2.05
Water of Composition	3.63	....
Iron peroxide	.603	2.55
Oxygen	7.036	....
Baryta	.724	1.12
Insoluble	1.728	2.80
Phosphoric acid	....	1.029
Manganese oxides	84.620	....
Peroxide of manganese	....	90.15
Lime	....	trace.

Ores less crystalline but equally pure occur at Loch Lomond in Cape Breton County, at the Moseley Mines. The ore is found in both the crystalline and amorphous forms in a red shale of lower carboniferous age about five feet thick. It is presented as layers and beds from one to eighteen inches in thickness. The enclosing material being soft it is readily extracted. The position of the mine has necessitated unfavorable conditions for shipment, but the construction of the railway now under contract between the Strait of Canso and Louisburg will furnish a ready access to admirable shipping facilities.

The following analyses will serve to show its quality:—

	I.	II.	III.
Peroxide of manganese (available)....	91.84	87.64	92.65
Peroxide of iron......................	.12	trace.	4.14
Insoluble.............................	2.71	8.51	trace.

The ores of this metal occnr in workable amounts in Onslow, near Truro, as veins, and in the partings of the lower carboniferous sandstones.

During the past few months New Ross, in the northern part of Lunenburg County, has promised to become a producer of manganese ores. Miner T. Foster has opened a number of veins which are of high grade, and available for economic extraction. A few tons have been shipped, and have found a ready sale. The extent of the manganiferous ground, and the age of the strata holding the ores, has, I believe, not yet been worked out. Explorations made during the past season, have shown that the Dean and Chapter lands adjoining the Foster properties contain, at several points, deposits which promise to be valuable. The ores of this district have, so far as I can learn, not been exhaustively analysed. They contain, however, manganese in amount suitable for steel and chemical purposes.

The Mineral Products Company of Bridgeville, Pictou County, also exhibit samples of manganite, and of manganiferous limonite. It is reported that recent developments in the iron ore mines of this locality have shown the presence of considerable amounts of the latter mineral.

Gold Ores.

The collection of gold specimens procured for the exhibition although not as rich as could be desired, may be termed representative of a number of the best known districts. I will refer briefly to the districts represented. The department contributed a set of Montagu specimens, valued at $1,200.00, at present on exhibition at the Imperial Institute, London, also specimens from Renfrew, Mt. Uniacke, and Waverly. Another handsome set, approaching in value that first named, was secured from Messrs. Jack & Bell. Another sample was from the famous "Plough Lead" at Isaacs Harbor.

The following parties also contributed samples, some of which were very handsome, accompanied by samples of concentrates, wall rocks, photos, etc.:

J. J. Withrow	South Uniacke	Gold-beariug quartz.
"	"	Concentrates.
J. Hirschfield	Goldenville	"
Guffey Jennings	Caribou	Gold-bearing quartz.
W. C. Sarre	Cow Bay	"
Cashon & Hines	Leipsigate	"
"	"	Concentrates.
Elk Mining Co	Caribou	Gold-bearing quartz.
"	"	Concentrates.
Montreal & London Gold Dev. Co	Salmon River	Gold-bearing quartz.
Gue & Wilson	Waverley	"
R. R. McLeod	Malaga	"
J. H. Townsend	Lawrencetown	"
"	"	"
"	"	Wall rocks, etc.
W. L. Libbey	N. Brookfield	Gold-bearing quartz.
"	"	Wall rocks.
"	"	Concentrates.

Note.—At this mine there is a successful chlorination plan, the first in the Province.

J. D. Huntingdon	Yarmouth	Gold-bearing quartz.
"	"	Concentrates.
W. C. Anderson	Montagu	Gold-bearing quartz.
Jack & Bell	"	"
Cunningham & Curren	Mount Uniacke	"
"	"	Concentrates.
J. D. McGregor	Fifteen Mile Stream	Gold-bearing quartz.

Lead.

As yet the development of our lead ores has not reached the productive stage.

In Inverness County, in Laurentian felsites, at many points, are visible the effects of solfataric action, in deposits of copper, lead and zinc ores, often noticeably enriched with gold and silver. Some measure of development has been attained at Cheticamp by Halifax capitalists, who have opened a promising silver lead deposit. It is expected that these ores will be shipped to the smelter at Pictou, or to Swansea. Openings show the deposit to be from 3 to 10 feet thick, and to continue for several hundred feet. Roughly speaking, the ore carries one ounce of silver for each unit of lead, some samples showing as high as 78 per cent. of lead and 80 ounces of silver. Gold also shows in quantities varying from 3 to 14 dwts. per ton of 2,000 lbs. Similar results in gold and silver have been obtained from the Silver Cliff deposits and from zinc blende deposits in the same locality.

As yet the auriferous alluvium in the Cheticamp River has not received systematic attention. If there are gravels in the river worth working, they will be found where the river leaves the mountain, and not in its narrow gorges subject to frequent and severe freshets. No free gold veins have yet been reported, and the alluvial gold which attracted so much attention some time ago is probably derived from the felsites, which are reported to occasionally show fine flakes of gold.

At Red Head, a few miles to the north, some development work has been done on copper deposits, also auriferous. Galena

ore running high in lead and silver occurs at Caledonia, Guysboro County, and at Smithfield, Hants County.

Graphite.

The upper or slate division of the Nova Scotia gold fields frequently shows beds highly carbonaceous, but I am not aware that they have been practically tested. In the precambrian felsites and gneisses of Cape Breton, plumbaginous slates are not uncommon. Samples have been secured from the River Dennys district, and from the vicinity of the Grand Narrows. The rock from the latter locality yielded to the analyst of the Geological Survey:

Graphite Carbon	50.23
Rock matter	43.27
Water	6.50
	100.00

Copper.

An interesting set of specimens and photos show the development work of the Cape Breton Copper Company at Coxheath, Cape Breton County. Here a number of deposits have been traced for several thousand feet, and proved to depths upwards of 300 feet. The deposits vary in thickness up to 12 feet, and may, so far as exploration work has been carried, be described as very long lenses, bedded in precambrian felsites and slates.

While some of the lenses carry copper contents up to 10 per cent., the ore will presumably belong to the class requiring concentration. Working tests have shown that concentration readily presents a suitable furnace material, unusually free from injurious ingredients. The following tables of analyses and of working tests of concentration are of interest:

CAPE BRETON COPPER COMPANY, (LIMITED), NOVA SCOTIA, CANADA.

Analyses of Coxheath Copper Ores.

	LUCIUS PITKIN, New York.	FRED CLAUDET, London.	PROF. HOFMAN, Boston.	DR. EDW. D. PETERS, JR., Boston.		
Copper	6.04	8.99	6.79	13.4	5.3	3 14
Iron	14.11	12.83	15.79	13.62	9.84	7.18
Sulphur	10.69	13.40	8.10	18.1	11.13	8.64
Silica	46.23	61.63	47.47	52.7	69.8	73.64
Arsenic.	0.01	0.05	0.012	....	....	....
Antimony.	0.17	traces.	none.	....	....	....
Lime	2.34	1.05	trace.	....	....	....
Magnesia	2,27	0.32	3 88	....	....	....
Alumina	11.83	0.94	8 02	....	....	....
Cobalt	....	0.06	....	....	....	....
Lead	none.	....	....	....	....	....
Bismuth	0.001	....	....	....	....	....
Zinc	none.	....	....	....	....	....
Nickel	0.36	....	....	....	....	....
Phosphates.	0.08	....	....	....	....	....
Oxygen & loss.	....	.73	....	....	....	....

Gold and Silver Assays.

Copper.	Gold.	Silver.
	ozs. Selected Ores.	ozs.
29.6	0.17	....
17.	0.195	0.45
18.4	0.15	2.07
25.2	0.26	4.5
15.7	0.26	3.5
8.52	0.15	4.5
6.89	0.06	0.22
5.62	0.05	0.40
	Concentrates.	
7.23	0.7	
9.50	0.3	
12.61	0.5	
	Tailings.	
1.90	0.025	
2.05	0.01	
	Slimes.	
3.	0.02	

CAPE BRETON COPPER COMPANY, (LIMITED), NOVA SCOTIA, CANADA.

TABLE I.

Designation.	Pryites.					Mixed Products.					Waste.				
	No. of Sample.	Wet Weight.	H20.	Dry Weight.	Cu.	No. of sample.	Wet Weight.	H 20.	Dry Weight.	Cu.	No. of sample.	Wet Weight.	H 20.	Dry Weight.	Cu.
		Ko.	%	Ko.	%		Ko.	%	Ko.	%		Ko.	%	Ko.	%
Raw Ore, stated weight.	1	3190	0.3	3180	3.46	.	....	....	....	Roller stuff concentrated for furtherdressing.					
Grains from 8-5-6 mm....	2	....	Dried.	16.1	11.35	10	230	2.2	225						
" 5-6 4 mm....	3	....		42.7	11.30	11	609	3.4	588						
" 4-2-8 mm....	4	....		61.8	10.97	12	775	4.0	744		19	123	4.2	118	1.05
" 2-8-2 mm....	5	....		23.6	12.31	13	282	7.2	262		20	169	6.8	157.5	
" 2-1-4 mm....	6	....		45.3	.....	14	507	7.5	469		21	249	6.0	234	
Schlich from	7	267	12.0	235.	12.79	15	612	10.2	551	290	22	897	11.3	396	0.82
Jigger under.....		....	...	....	.....		....	....	....	.....	23	368	26.6	270	0.98
1·4 mm.		....	....	....	.....		....	....	....	.....	24	213	29.6	150	
do. from Rittinger......	8	56.2	16.1	47.2	15.39	16	108.5	24.8	81.5	3.80	..	....	....	....	....
do. turning table........	9	46.6	19.5	37.6	14.14	17	53	24.0	40.5						
Schlamm (slimes) from flours................		....	....	... .	.....	18	149	27.7	108	4 27	..	....	....	....	....
do. from clarification pit		... .	....	....	.....		....	....	....	.....	25	....	....	164.2	365
				509.3					781					1889.7	
Returns		....	....	16.016%	. ..		....	....	24.56%	.....	..	....	....	59.43%	....

In regular work there will be obtained from the 781 Kos. mixed products still about 80 Ko. Schlich, so that the total yield would amount fo 18.5 %.

Concentration trials on Coxheath Ore, by Humboldt Works, Kalk, Germany.

CAPE BRETON COPPER COMPANY, (LIMITED), NOVA SCOTIA, CANADA.

TABLE II.

Designation.	No. of sample.	Pyrites. Wet Weight.	Pyrites. H 20.	Pyrites. Dry Weight.	Pyrites. Cu.	No. of sample.	Mixed Products. Wet Weigtht.	Mixed Products. H 20	Mixed Products. Dry Weight.	Mixed Products. Cu.	No. of sample.	Waste. Wet Weight.	Waste. H 20.	Waste. Dry Weight.	Waste. Cu.
		Ko.	%	Ko.	½		Ko.	%	Ko.	%		Ko.	%	Ko.	%
Raw Ore, stated weight..	26	3551	0.23	3543	2.26	..	....	....	....	....	..	......	....	......	....
Grains from :															
8-5-6 mm.	27	....	....	17.4	8.18	36	443	4.0	425	Roller stuff concentrated and dressed again.	..	....	....	....	....
" 5-6-4 "	28	....	....	25 4	8.15	37	680	4.0	657		45	250	3.4	241.5	
" 4-2-8 "	29	....	....	36.5	8.10	38	821	3.8	790		46	65.5	10.0	59	.97
" 2-8-2 "	30	....	....	10.4	8.70	39	341	7.5	316		47	338.5	7.0	314.8	
" 2-1 4 "	31	....	....	34.3		40	566	14.0	487		48	1199	11.7	1059	0.85
Schlich from :															
Jigger under ¼ mm.	32	175	14.4	149.8	9.78	41	283	18.0	232	3.85	..	....	....	......	....
Schlich I. Iron pyrites from Rittinger	33	....	....	8	2 30	..	....	....	....	....	..	....	....	......	....
Schlich II, Copper pyrites from Rittinger ...	34	45.5	18.4	37.1	14.10	42	156	25.0	117	2.44	49	398	26.0	294.5	0.66
Schlich from turning table	35	50.4	20.4	40.1	9.87	43	62.5	25.0	47		50	220	28.7	157.2	
Schlamm from labyrinth (flour)	..	....	....	....	....	44	218	31.4	150	3.40	.	....	....	....	...
Schlamm from Clarification pit:															
Remains not treated	..	....	....	....	....	52	34	3.0	33	1.17	51	....	....	476	2.56
				362					579					2602	
Returns		.... ..	....	10.217%	.....	..	....	....	16 34%	......	..	....	...	73.44%	...

In regular work there will be obtained from the 579 Klg. mixed products still about 60 Kos. Schlichs, so that the total yield would amount to 11,85%.

Concentration trials on Coxheath Ore, by Humboldt Works, Kalk, Germany.

Samples of similar ores are shown from St. George's River, Eagle Head and French Road, in the same County.

In Antigonish County the traces of copper ore are wide spread. At some points prospecting work has given promising results, but as yet the various licenses to search have received little attention.

A sample of copper ore from St. Joseph's is from a bed of mixed chalcopyrite and shale in lower carboniferous strata close to their junction with precarboniferous rocks, presumably of lower silurian age. There are about eight beds, reported to be from two to six feet in width The following analysis of a sample from the No. 2 vein is by the Geological Survey Department:

Copper	27.00	Moisture	.20
Iron	29.70	Carbonate of Iron	6 20
Sulphur	33.50		
Silica	3.40		100.00

At Polson's Lake somewhat extensive development work has shown, in Devonian strata, beside a dioritic dyke, a large mass of carbonate of iron and calc spar carrying copper pyrites. The ore is stated to average from 9 to 16 per cent. of copper, and to carry several dollars' worth of gold and silver. On the opposite or west side of the Lochaber lake, similar but richer ores occur in numerous veins with spar and specular iron. Exploratory work done here a number of years ago was fairly promising.

In addition to these deposits, carbonates, sulphides and silicates of copper are not uncommon in the carboniferous shales and sandstones in irregular masses, frequently rich, but limited in extent. Further work may, however, show localities where this class of deposits will reach economic values.

In Pictou County similar ores occur at a number of places in the permo-carboniferous and in the millstone grit and lower carboniferous. Traces of copper sulphide also occur in the district forming the water shed between the Bay of Fundy and

the Strait of Northumberland. The deposits near Pictou and River John have received some attention and will probably prove sources of this metal. At Dalhousie Mountain a good deal of surface exploration has been done on a vein from 2 to 3 feet wide carrying copper pyrites. Samples have shown up to 15 per cent. of copper and about $26.00 of gold per ton.

It may be anticipated that where the Devonian strata of this district are intersected by dioritic and granitic dykes opportunity will be afforded for copper ores, in some cases, of commercial value. The rocks referred to appear again in the southern part of New Annan, and indications of copper ore are wide spread in quartzites and felsites associated with dioritic dykes, etc.

Developments have been made at New Annan, on the East Branch of the French River, about five miles from Tatamagouche Station. The property being developed presents a bed about four feet thick, carrying stringers of black sulphide and carbonate with nodules of various copper sulphides in a fine sandstone conglomerate resting on a blue clay floor. Similar deposits also occur at the Palmer mine, near Wentworth. Here the bed is about ten feet thick and much mixed with clay. The quality of these ores varies very much, according to the state of concentration reached in the process of formation. Samples can be had running up to 50 per cent of copper, with gold and silver in varying amounts. It is expected that these deposits and others of a similar character scattered from Amherst to Pictou will furnish material for the smelter at Pictou. More extended development will be required to determine this point. It is, however, extremely probably that the older rocks lying to the south of the carboniferous will yield deposits of ore larger and more uniform in quality.

Copper pyrites also occurs on the Portapique River, Colchester Co., in a stratum, presumably of Devonian age, over a tract several hundred feet wide and a mile in length. Samples show up to 20 per cent. copper, with traces of gold.

Iron.

Among the most interesting of the exhibits under this head is that of the Nova Scotia Steel Company. This company is an example of the successful progress of enterprise combined with commercial and technical skill. The forge works of New Glasgow, which acquired well-deserved notice for their work in ship frames, shafts, stems, etc., gradually grew and prospered With the iron ores and coal of Pictou County at the doors of New Glasgow, it needed one step and the company produced its own raw material. A railway was built from Hopewell to the head of the East River, to open the Bridgeville iron ores and limestones. A furnace was built at the junction of the East and West branches of the East River, and a large steel works made Trenton another New Glasgow.

This measure of progress has not limited the company's ambition. By a lucky stroke of business they acquired possession of an enormous iron ore deposit on the coast of Newfoundland. This deposit was capable of yielding at the cheapest rate an ore suitable for the basic process. Accordingly large amounts have been annually imported for mixture with the limonite ores of Bridgeville. Exports have also been made to the United States and Europe. The company has sold part of this deposit to the Dominion Iron and Steel Company, it is said, for the sum of $1,000,000 00. Now they propose to absorb the 22 square miles of coal area of the General Mining Association and to erect at North Sydney a steel plant rivaling that of the Dominion Steel Company.

The ores of the Pictou iron field comprise limonites, red hematites, and spathic and specular ores. As yet operations have been confined to the limonites mined by the Steel Co. There are enormous deposits of red hematites and specular ores yet untouched, and affording material for the establishment of an iron industry surpassing that contemplated at the Sydneys.

The samples exhibited by the company comprise ores, fluxes, fuels, pig iron, and the steel products.

The transactions of the Nova Scotia Mining Institute contain a full description of the plant of this company. The following analyses are self-explanatory:

Nova Scotia Steel Company, Trenton and Ferrona.

Iron Ores.

Red Hematite from Wakana Mine, Newfoundland, owned by N. S. Steel Co. Average analysis for year 1898 at 150,000 tons. Dried at 212° F. Moisture, 0.66.

Loss on ignition....	2.08	p. c.	Phos-Acid	1.62	p. c.
Silica...............	11.57	"	Sulphuric Acid......	0.07	"
Iron Oxide	77.67	"	Titanic Acid.........	0.25	"
Manganese Oxide....	0.08	"	Metallic Iron........	54.37	"
Alumina............	4.55	"	Phosphorus.........	0 71	"
Lime (CaO.)........	1.81	"	Sulphur.............	0.03	"
Magnesia...........	0.44	"			

Magnetic Iron ore from Cuba, dried at 212 F. Average analysis:

Silica...............	9.91	p. c.	Manganese..........	0.41	p. c.
Alumina............	0.85	"	Metallic Iron........	61.02	"
Lime	0.50	"	Phosphorus.........	0.04	"
Magnesia	0.32	"	Sulphur.............	0.087	"

Red Hematite. (High phosphorus.) Torbrook, N. S.:

Silica	13.00	p. c.	Titanium...............	Trace.	
Ferric Oxide	77.60	"	Barium Oxide	"	
Alumina............	4.28	"	Volatile matter...........	Nil.	
Manganese Dioxide..	0.38	"	Carbonic Oxide..........	"	
Calcium Oxide.......	1.90	"	Phosphorus.........	1.21	p. c.
Magnesium Oxide ...	0.35	"			

Limonite Iron ore, washed sample, from East River, Pictou. Average analysis:

Comb. water........	12.40	p. c.	Magnesia	0.16	p. c.
Silica...............	11.25	"	Manganese..........	0.33	"
Ferric Oxides.......	73.23	"	Phosphorus..........	0.032	"
Alumina............	1.49	"	Sulphur.............	0.084	"
Lime...............	0.39	"	Metallic Iron........	51.26	"

Limonite—Lump sample from East River:

Comb. water	10.50 p. c.	Magnesia	0.21 p. c.
Silica	8.18 "	Manganese	1.25 "
Ferric Oxide	76.30 "	Phosphorus	0.02 "
Alumina	2.10 "	Sulphur	0.06 "
Lime	0.31 "	Metallic Iron	53.41 "

Fluxes.

Limestone, Springville, Pictou Co. Average analysis:

Moisture	0.20 p. c.	Magnesium Carbonate	4.90 p. c.
Silica	3.10 "	Calcium Sulphate	0.20 "
Alumina	0.24 "	Organic matter	—
Ferric Oxide	1.86 "	Lime } Available	49.81 "
Calcium Carbonate	88.94 "	Magnesia } Available	2.35 "

Pig Iron.

No. 1 Foundry.		Basic Iron.	
Silicon	2.85 p. c.	Silicon	0.40 p. c.
Manganese	0.54 "	Manganese	0.75 "
Phosphorus	0.90 "	Phosphorus	1.00 "
Sulphur	0.01 "	Sulphur	0.03 "
Gr. Carbon	3.70 "	Graphitic Carbon	3.27 "
Comb Carbon	0.16 "	Combined Carbon	0.63 "
Copper	Nil.	Copper	Nil.
Arsenic	"	Arsenic	"
Barium	Trace.	Barium	Trace.

Hematite Iron.		No. 2 Foundry.	
Silicon	1.00 p. c.	Silicon	2.50 p. c.
Manganese	0.95 "	Manganese	0.55 "
Phosphorus	0.08 "	Phosphorus	0.90 "
Sulphur	0.08 "	Sulphur	0.012 "
Gr. Carbon	3.12 "	Gr. Carbon	3.20 "
Comb. Carbon	0.70 "	Comb Carbon	0.30 "
Copper	Nil.	Copper	Nil.
Arsenic	"	Arsenic	"
Barium	Trace.	Barium	Trace.

No. 3 Foundry.		No. 4 Foundry.	
Silicon	2.10 p. c.	Silicon	1.75 p. c.
Manganese	0.60 "	Manganese	0.65 "
Phosphorus	0.91 "	Phosphorus	0.92 "
Sulphur	0.02 "	Sulphur	0.03 "
Gr. Carbon	2.50 "	Gr. Carbon	2.00 "
Comb. Carbon	0.60 "	Comb. Carbon	0.90 "
Copper	Nil.	Copper	Nil.
Arsenic	"	Arsenic	"
Barium	Trace.	Barium	Trace.

Fuels.

48 hour (Retort) Coke. Made in "Bernard's" Coke oven, from washed coal at Ferrona Iron Works.

Moisture	0.40 p. c.	Ash	7.22 p. c.
Vol. Comb Matter	1.60 "	Sulphur	1.15 "
Fixed Carbon (by diff.)	90.78 "	Phosphorus	0.01 "

Slate, etc., from coal washer from coal used in making coke.

Moisture	1.00 p. c.	Ash	76.31 p. c.
Vol. Comb. Matter	18.14 "	Sulphur	6.23 "
Fixed Carbon	4.55 "		

Washed coal used for making coke.

Moisture	1.07 p. c.	Ash	4.17 p. c.
Vol. Comb. Matter	31.69 "	Sulphur	1.46 "
Fixed Carbon	63.14 "		

Culm Coal, one-third Springhill and two-thirds Reserve Coal, (C. B.)

Moisture	0.82 p. c.	Ash	11.06 p. c.
Vol Comb. Matter	28.31 "	Sulphur	2.12 "
Fixed Carbon	59.87 "		

Another interesting exhibit is that of the Mineral Products Company, of Bridgeville, Pictou County. These people leased the Charcoal furnace at that place for the manufacture of ferro-manganese. The manganese was obtained from a deposit in New Brunswick. This deposit consisted of bog ore, which was dried and made into briquettes. It was smelted with the limonite ore of the East River, and made a product of good marketable value. The expense incurred in handling the manganese ore and its freight has been assigned as the cause of the abandonment of the enterprise. I regret to say that, owing to the absence of the manager from the Province, I am unable to give analyses of the raw materials and of the product.

In this district, in addition to the limonite ores, there are large deposits of specular, red hematite, spaltic and clay ironstone ores, which will no doubt before long be mined for the smelter.

In Cape Breton as yet there has been little iron ore development. An extensive and valuable deposit at Gillis Lake, is known as the Moseley mine.

The following set of analyses will tend to show its quality:

	1.	2.	3.	4.
Iron	63.45	63.20	58.90	64.10
Silica	6.96	6.42	13.38	4.71
Phosphorus	.0212	.014	.0257	nil.
Sulphur	.0631	.0604	.0041	.0027

The bed, which has been traced for several miles, averages about seven feet in thickness, and is associated with a crystalline limestone, presumably of laurentian age. It is within about four miles of deep water, and about eight miles from the Intercolonial Railway.

In the devonian strata in the neighborhood of St. Peter's, Richmond County, there are a number of deposits of specular ore, similar to those found in strata of the same age in Guysboro County.

The following analysis from the Micmac mine, about six miles from St. Peter's, will serve to show the class of this ore:

Iron	68.18	Sulphur	.15
Silica	2.48	Phosphorus	.05

Prospecting work at Whycocomagh, Cape Breton, has shown the presence of a number of beds of magnetite and red hematite up to twelve feet in thickness. Judging from surface indications, there is an extensive iron field in this locality. Analyses show metallic iron, from 49.13 to 63.20; Silica, up to 21.90; Sulphur, trace to .55; Phosphorus, trace to .49.

Very extensive deposits of a similar character occur at Nictaux, Annapolis Co., and are represented by a number of samples. A deposit of red hematite, at Torbrook, in this district, about six feet thick, was worked for some years, until the Londonderry Furnaces were closed. A description of the ores and analyses will be found in a paper on the Iron Ores of Nictaux read by me before this Institute a few years ago.

Other localities which have been drawn upon for samples are briefly as follows: Mira River, Cape Breton County, where there are several beds of red hematite from three to six feet thick.

Extensive deposits of magnetite and red hematite are reported from George's River, in the same county. As yet the explorations in these deposits have not been carried to any extent. The following analysis by F. A. Mason, of Halifax, will show that rich ore exists:

Metallic Iron	58.56	Phosphorus	.019
Manganese	1.98	Sulphur	.013
Silica	5.79	Titanium	.95

Londonderry, Colchester County, has for many years yielded limonite ore of very high quality. A very elaborate report and analyses were made some years ago by Dr. Selwyn, and published in the report of the Canadian Geological Survey Samples of the varieties of limonite and specular ores, and of the carbonates, etc., worked here have been forwarded.

Quarries.

These notes refer to the Quarries in the northern part of Cumberland County, which furnished samples of their products.

Quarries at River John.—No. 1. This is the only quarry at present working in this district. It is situated at River John and about a quarter of a mile from I. C. Railway, and connected therewith by a good road.

It contains a reddish sandstone of fine grain, and has been opened for about 350 feet in length, exposing a face so far of about 14 feet. Stones are cut here up to about 33 cubic feet, though almost any size could be obtained with larger machinery. The seams are very regular in formation and lie nearly horizontal. Worked for nearly a year.

No. 2. Adjoins the first quarry, and resembles it in general characteristics, though the stone is of a lighter colour.

No. 3. About a quarter of a mile up the river from No. 1, was worked for six years intermittently. Many grindstones were cut in this quarry, which yields a firm grey sandstone.

Wallace Harbor.—The Wallace Grey Stone Co., Wallace Harbor, John Stevenson, Manager. This quarry is situated at Wallace, and a great part of the stone is shipped by water, though it is connected with the I. C. Railway by a good waggon road about two miles long.

Though the stone is carried to the wharf by horses, a tramway (gravity) could easily be operated, the quarry being situated on a hill. The distance is about a quarter of a mile. This quarry has been worked for a period of nearly thirty years off and on, and is still only partially developed. It produces an average of about 1,500 tons ("quarry") a year, of fine grained sandstone in two colours—"olive" and "bluish."

Blocks up to ten tons in weight and measuring fourteen feet are cut, and the greater part of the stone is shipped to the Boston and New York markets. The poorer stone is sold locally.

Wallace Harbor.—The G. P. Sherwood Co., T. C. Dobson, Manager. This quarry adjoins the quarry of the Wallace Grey Stone Co., and the same remarks apply to it also.

At Wallace Bridge the famous Battye Quarry is being operated by George Battye. Stone has been taken from this quarry since the year 1809, and there is still much in sight. It is situated on the I. C. Railway and the Wallace River. Chief market New York and Eastern States' cities. Blocks up to ten tons are cut. At present 25 feet of rock is shown in the face, with seams measuring from 2 to 6 feet in thickness. This is composed of a very uniform and beautiful sandstone, suitable for monumental as well as construction work.

On the River Philip, about five miles from Pugwash, is situated the quarry of McLeod & Embree. It produces a handsome red sandstone contained in seams from 2 to 7 feet, and shows altogether 20 feet in the face. Blocks cut to 8 tons. Has been operated for upwards of 30 years and usually ships to the

States. This year all the stone quarried is being supplied to Toronto.

The Atlantic Stone Co., Limited, R. S. Hibbard, Manager.—The quarry of this company is situated on Cumberland Basin, 3½ miles from Joggins Station, on the Canada Coal Company's Railway, and 16 miles from I. C. Railway. The stone is shipped chiefly by water, in vessels up to about 300 tons. The market is mainly in the New England States, though the stones are sent much further west occasionally. 2,000 tons shipped per year. This quarry produces a very superior form of grindstone. Stones from half an inch to 14 inches thick, and up to 7 feet in diameter are cut, though almost any size that could be handled are procurable.

At Lime Rock, West River, Pictou Co , are sandstone quarries yielding good building stone. Samples are shown by Mr. J. H. Fraser. In the Merigomish district the strata lying above the productive measures yield grindstones and fair qualities of freestone.

The owners of quarries of granite, syenite, etc., neglected to respond to the invitation of the Department to send samples. The demand for granite is limited practically to the City of Halifax, where this stone is used to some extent for foundations, trimmings, and in the fortifications. The present available sources of supply are Shelburne, and the North-West Arm, near Halifax. At Nictaux there are blue varieties of granite of very fine quality, and in Cape Breton there are syenites, gneisses, etc., available for decorative and other purposes.

An interesting deposit of sandstones yielding building stone, grindstones, whetstone, etc., is found at Lower Cove, Joggins, Cumberland County. Samples of the raw and manufactured article are contributed by Mr. R. L. Hibbard. These quarries have been worked continuously for many years, and an extended market has been found for the grindstones. The quarry yields stones one-half to seven inches in thickness and up to seven feet in diameter. The superior quality of these

stones has secured a reputation for the district second only to that acquired by quarries more favorably situated in large industrial districts. Similar deposits are known at several places along the Joggins shore.

Marbles are represented by a sample from Escasoni, Cape Breton County, contributed by Mr E. T. Bown.

The following list shows the building stone quarries from which samples have been secured for the Exhibition:—A. Allen, W. W. Garmon, River John; T. C. Dobson, Wallace; McLeod & Embree, Pugwash; Wallace Graystone Company, Wallace; A. McPherson, Eight Mile Brook; R. L. Hibbard, Joggins; J. H. Fraser, Limebrook.

Barytes.

This mineral is known at Five Islands, Stewiacke, River John, and at Lake Ainslie, in Cape Breton. At present a few hundred tons are annually mined at the last-named locality. The ore occurs in a vein about nine feet wide, and is extracted through a tunnel. It is of excellent color and quality, and low in carbonate of lime. Samples of this mineral are exhibited by Messrs. Henderson & Potts.

Gypsum.

This mineral is found in great abundance in Nova Scotia. It is presented as hard and soft gypsum in every variety of texture and purity. The annual production is about 150,000 tons, principally from Hants County. Small amounts are quarried at other localities for local use, as an ingredient for fertilizers, etc. The exports from Hants County go to the United States, and a considerable shipment is made from Victoria County to Montreal and Philadelphia. Samples are exhibited from Windsor, Wentworth, St. Croix, Newport and other localities, in Hants County. Selenite is also shown from Enfield, in the same county, which has yielded a few hundred tons.

The Windsor Plaster Company also show the following products: (1) "Calcined plaster" used for putty coating, finishing, etc. (2) "Selenite cement" used for under coating, etc. (3) "Land plaster," ground gypsum, used for fertiliser manufacture, stables, etc.

Tripolite.

Of late years considerable attention has been paid to the infusorial earth deposits of the province, and to deposits of very fine grained quartz available for polishing, insulating, and other purposes.

Among the localities represented may be mentioned River Dennys, Inverness Co., where the Cairo Polishing Company are doing development work; Bass River, Colchester Co., where extensive works are carried on, the shipments for the last fiscal year amounting to 21 tons. The Bass River Infusorial Earth Company procure the raw material from Bass River Lake, where it is found in a bed about three feet thick, and purify it in a large plant, which has been in operation for over two years.

The Victoria Tripolite Company have commenced extensive operations near St. Ann's, in Victoria County, and are making a specialty of insulating material.

Molybdenite occurs at many points in the Province, but as yet deposits of workable size have not been reported. New Ross, Lunenburg, yields very large and fine crystals. A sample is shown from this district. A few tons have been shipped from Gabarus, Cape Breton County. From the Margaree district, Inverness County, are shown samples of ores of Tungsten, fuller reference to which will be found in these Transactions.

Antimony. The sulphide of this metal was some years ago worked intermittently at West Gore, Hants Co. The Messrs. McNeil, of Halifax, have lately given some attention to the district, and have proved three leads. The ore carries consider-

able gold values, and there appears to be some difficulty found in extracting it. Assays show the following values:

	I.	II.
Antimony..........	60.29 p. c.	43.73 p. c.
Gold	2.66 oz. per ton 2,000 lbs.	2.48 oz.
Silver..............	———————	.10 "

Fire clays occur at several places in the coal measures, and other horizons of the carboniferous, and are apparently valuable. The manufactnre of fire brick was carried on for some time at Stellarton, but is, I believe, at present discontinued.

Allied economically to the fire clay is a sample of felsite from Coxheath, Cape Breton Co., which has been proven experimentally to make a good fire brick when mixed with about one per cent. of lime.

Samples of coal oil shale and their products of parafine, wax, illuminating and lubricating oil are shown from East Bay, Cape Breton Co., where a plant is being erected to treat them on a large scale. These shales occur in lower carboniferous conglomerates and sandstones near their junction with laurentian measures.

XI.—On the Variation of the Rigidity of Vulcanized India-Rubber, with Tension.—By Thomas C. Hebb, B. A., *Dalhousie College, Halifax, N. S.*

(Communicated by Prof J. G. MacGregor on the 14th May, 1900.)

Mr. W. A. Macdonald* found in the course of experiments conducted in Dalhousie College last year, that the rigidity (kinetically determined) of a fresh or partially fatigued vulcanized india-rubber cord, when subjected to increasing tension, at first diminished, then reached a minimum, and finally increased; while in the case of a sufficiently fatigued cord, the minimum point seemed to disappear. But owing to a doubtful mode of gripping the ends of the cord, his experiments were not conclusive.

At Prof. MacGregor's suggestion, I have made the experiments described below with the object of settling this question and finding out what I could about the phenomenon.

For this purpose I have (1) used the method of gripping the cord which Mr. Macdonald employed in his last series of experiments in order to exclude the source of error affecting his earlier observations; (2) applied the static as well as the kinetic method of determining the rigidity; (3) made experiments both on the cord which Mr. Macdonald used and on fresh cords, and (4) adopted modes of procedure, suggested by the results of my earlier experiments, with respect to the time between the loading of the cord and the determination of the rigidity, and to the magnitude of the angle of torsion.

The cords used were cylindrical in section, about forty inches in length, and one-third of an inch in diameter. The grips consisted of pieces of brass tubing of the same diameter (inside) as the cord, in one end of each of which three longitudinal cuts had been made. The ends of the rubber cord were drawn into

---

* Proc. N. S. Inst. Sci., 10, 28, 1898-99.

the cut ends of these brass tubes and firmly fastened there by wire twisted around the tubes outside. Cords of considerable length were used, in order that the effect of the gripping at the ends might be inappreciable.

The cords were suspended from an iron bracket, moveable on vertical guide-posts which were attached to the wall of the laboratory, and capable of being firmly clamped to these posts at any desired elevation.

The upper brass tube passed through a wooden socket firmly fixed in the bracket. It was held in this socket by friction, and while it could be rotated by hand, there was no danger of its shifting its position otherwise. The brass tube projected above the socket, and carried a wooden disk, on which was a divided circle. A pointer fixed over the disk indicated the number of degrees through which the cord was twisted. Thus any desired torsion could be given to the cord at the upper end.

The brass tube at the lower end of the cord carried, in a plane perpendicular to it, a light wooden arm for the application of the twisting force in the static experiments, and which served as a platform for the stretching weights.

These weights were square leaden plates of about four inches' edge. They had holes of the size of the brass tube cut in the centres, and slits leading to them from the edge, so that they could be easily put on and taken off.

In applying the kinetic method, the cord was kept fixed at the top, while the lower end, with the plates attached, was twisted through some angle and then let go. The time of oscillation was then determined by means of a stop-watch. This datum, together with other data easily obtained, viz., length and diameter of cord, and moment of inertia of plates, gave the means of finding the rigidity. In determining the time of oscillation, it was soon noticed that it varied with the angle through which the cord was twisted. Hence the cord was always twisted through known angles. In the static, as in

the kinetic method, the rigidity varied with the angle, and here, also, definite angles of twist were always used.

In using the static method, the twisting force was applied at the end of the arm carried by the lower brass tube. In the earlier experiments it was applied by means of a thin silk string, horizontal and perpendicular to the arm, which passed over the pulley of a set of frictionless wheels taken from an Attwood's machine, and carried a small plummet of known weight. The plummet was so light that the cord was not appreciably deflected from the vertical. In order to make the friction as nearly as possible the same in all experiments with the same plummet, I observed the position of the end of the arm before the plummet was attached or the cord twisted, and then having attached the plummet, I determined the amount of twist to be applied in order that the arm might make small oscillations about this position.

Even with this procedure, however, successive observations showed a lack of agreement which was traceable to friction. Hence, in the later experiments, I used Mallock's* method of applying the force, which I found not only to give more consistent results, but to occupy less time. A small plummet of known weight which was suspended from the end of the arm by a fine silk string was drawn aside by a second silk string, which was kept horizontal, the two strings being in a plane perpendicular to the arm. The distance to which it was drawn aside was determined by the aid of a second plummet hanging freely from the end of the arm. The horizontal force at the end of the arm was then equal to the weight of the first plummet multiplied by the ratio of the distance to which it was drawn aside to the distance below the end of the arm of the point of junction of the two strings. These distances, together with the length of the arm, could be measured with considerable accuracy, and thus the torque to which the cord was subjected determined.

---

* Proc. R. S. L., 46, 233, 1889.

In most of the measurements made, the quantity under consideration was determined as a mean of several observations.

Lengths were measured by means of a beam compass reading to .01 inch. The limit of error of a mean value was found by comparing a number of such mean values with their mean, the greatest divergence being taken to be the possible error of a determination. It was found to be different according as it was the length of the cord or of a side of the Mallock triangle or of the arm, that was determined. In the two former cases the greatest divergence from the mean was .01 in., in the latter .005 in.

The diameters of the cords, which were approximately cylindrical, were found by means of a screw-gauge reading to .001 inch. The possible error was found by the above method to be .0005 in. Owing to the difference in diameter at different parts of the cord, it was found necessary to have marks on the cord, at which the measurements were always made.

The error that might be made in determining the angle of twist in the static method was estimated to be about a quarter of a degree.

The weight of the small plummet used in twisting the cord was found by means of a balance weighing to .001 grm. The method of weighing was that of substitution, and the limit of error was estimated to be .0005 grm.

The time of oscillation was found by means of a stop-watch divided into fifth-seconds, but capable of estimation to .1 sec. The limit of error was determined in the same way as in the case of length, and found to be about .04 sec.

In the static method the formula used for the calculation of the rigidity was the following: $n = 2\, T\, l/\pi r^4 \theta$ in which T is the torque in lb.-inch units, applied at lower end of cord, l is length of cord in inches, r is radius of cord in inches, and θ is angle twisted through measured in radians. For the kinetic method the formula: $n = 8\pi\, l\, I/t^2 r^4 g$ was used, in which l and r were

expressed as in the previous formula, I is moment of inertia expressed in lbs. and inches, and t is the time of a complete oscillation expressed in seconds. The moment of inertia of the plates used in stretching the cords was found by means of the following formula: $I = M(a^2 + b^2)/12$, in which M is mass of plates in lbs. and a and b are the lengths of sides of plates in inches. The moment of inertia of the brass tube at the end of the cord was found to be negligible.

The values of the rigidity determined as above would thus be expressed in inch-lb-second gravitational units.

The effects on the calculated values of the rigidity, of the above possible errors of the component observations, were calculated in a few cases, and were found in the static observations to be between 1.5% and 2.5%, and in the case of the kinetic observations to be between 2.5% and 3%.

My first observations were made on the cord which Mr. Macdonald had previously used. He had subjected it to repeated and prolonged extension, and found that the minimum point which in the earlier series of observations seemed to characterize the variation of its rigidity with tension finally disappeared. Since the time of his experiments it had lain for six months unstretched.

The static method was the only one employed, the torque being applied by means of the frictionless wheels. The procedure was as follows: First a weight was hung on the cord, and left there for at least a day. Then its rigidity was determined, after which the load was increased and the cord left for another day. On the third day the same process was repeated, and so on. It was not until later on in the experiments that the importance of allowing the loads to act for corresponding intervals of time was realized. The following table gives the results obtained:

TABLE I.

Date.	Temp. (°C.)	Length. (inches)	Diam. (inches).	Angle of Torsion, (degrees.)	Torque (lb.-in.)	Rigidity.	Load (lbs.)
Oct. 20..	.....	....	....	....	....	....	1.611
" 23.	17.5	46.82	.322	917	.0209	58	"
" 24.	17.4	49.68	.313	1013	.0209	62	2.150
" 26..	21.4	52.98	.303	625	.0117	69	2.678
" 26..	20.5	53.07	.302	1093	.0209	71	"
" 27..	19.5	56.96	.291	1235	.0209	78	3.216
" 30..	18.5	57.28	.291	713	.0117	77	"
" 30..	18.8	57.28	.291	1256	.0209	78	"
" 31.	17.8	61.82	.278	1373	.0209	92	3.758
Nov. 1.	19.5	66.88	.270	1545	.0209	99	4.289

Although the above table shows considerable disagreement between successive observations, due probably in some measure to friction, to difference of temperature slightly, and to inequality in the times of application of the loads, the values obtained clearly increase with the tension, and give no indication of a minimum point. This result is in agreement with Mr. Macdonald's last series of observations, and seems to show that the rigidity increases steadily with tension in a cord which has been subjected to sufficiently prolonged extension, provided at least a day is allowed to intervene between increasing the tension and determining the rigidity.

The next observations were made on a fresh cord of a different rubber from Mr. Macdonald's. It was harder, and contained 60 per cent of pure rubber, according to the statement of the manufacturer. A freshly-cut surface showed a dark gray colour.

All the series of observations given below were made on rubber cords of this kind.

Both static and kinetic methods were applied, very little time being allowed to intervene between the two determinations, in order that the cord might be in the same state, as

TABLE II.

Date.	Diam.	Kinetic Observations. Length.	Temp.	Mo. of Inertia.	Time of Oscillation. 360°.	180°.	90°.	Static Observations. Length.	Temp.	Torque. 90°.	31.5°.	Kinetic Rigidity. 360°.	180.°	90°	Static Rigidity. 90°.	31°5.	Load, (lbs)
Jan. 11	.....	......	....	....	......	......	....	......	....	.....	......	.....	..	.....	....	......	.561
" 16	.397	35.06	18.2	1.44	3.65	3.42	3.13	35.06	17.9	.01536	.00574	159	181	217	141	150	"
" 17	.394	35.58	18.9	2.88	5.22	5.19	4.85	35.64	17.5	.01444	.00531	163	165	188	139	146	1.089
" 18	.389	36.23	14.7	4.42	6.60	6.37	6.23	36.24	15.5	.01444	.00555	167	179	183	148	163	1.644
" 19	.385	36.85	16.6	5.90	7.97	7.65	7.34	36.88	18.2	.01304	.00483	162	176	191	142	150	2.183
" 19	.381	37.54	17.9	7.37	9.16	8.96	8.76	37.57	19.8	.01201	.00433	163	170	178	139	143	2.711
" 20	.381	37.61	17.0	7.37	9.17	8.99	8.69	37.62	17.4	.01191	.00422	163	169	178	138	140	"
" 22	.380	37.64	18.4	7.37	9.34	9.18	9.03	37.69	18.4	.01226	.00449	159	165	169	144	150	"
" 22	.376	38.32	18.4	8.83	10.63	10.34	10.02	38.35	18.3	.01116	.00411	156	165	176	139	146	3.249
" 23	.376	38.43	18.3	8.83	10.47	9.93	9.41	38.46	18.3	.01120	.00397	161	180	199	140	142	"
" 24	.372	39.24	18.5	10.30	11.59	11.11	10.60	39.26	18.2	.01055	.00381	164	178	196	140	145	3.791
" 25	.366	40.18	15.0	11.74	12.67	12.41	11.93	40.18	15.5	.01026	.00368	170	177	192	149	153	4.322
" 26	.362	41.05	17.4	13.24	13.97	13.71	13.41	41.05	17.7	.00945	.....	169	175	183	147	......	4.869
" 27	.356	42.11	14.8	14.75	15.10	14.76	14.53	42.14	14.5	.00891	.....	176	185	191	152	......	5.422

nearly as possible, in both. In the static determinations of this, and of all subsequent series, Mallock's mode of applying the twisting force was used. The kinetic observations were made with different amplitudes of angle of oscillation, and the static observations with different angles of torsion. The general procedure was as in the former case. Table II contains the results.

In none of the columns of rigidity values of this table do the values found indicate any simple law of variation with tension. They do not even increase or decrease continuously as tension increases, but appear to oscillate between increment and decrement, and by amounts which are not accounted for merely by errors of observation. The variations cannot be accounted for even by errors of method, because in general both methods give similar variations. They may, perhaps, be partially at least, accounted for by defective procedure. Nevertheless, two conclusions may be drawn :—(1) The smaller the angle of torsion in the static determinations and the angle of oscillation in the kinetic determinations, the greater is the value of the rigidity obtained. Mallock drew the same conclusion as to kinetic rigidities from his observations. (2) The kinetic determinations show a point of minimum rigidity as tension increases; but the static determinations are not sufficiently exact to be decisive as to whether or not the existence of this point is independent of the method. Thus the kinetic observations bear out Mr. Macdonald's result that the kinetic rigidity exhibits the minimum point in the case of a cord previously unstretched.

The cord used in the last experiment being now in a state of tension, was experimented on in a reverse manner. It was left a day under the full load, when its rigidity was determined. Then one of the weights was taken off, and it was again left for a day under the diminished load, and its rigidity determined; and so on.

TABLE III.

Date		Diam.	Kinetic Observations.						Static Observations.			Kinetic Rigidity.			Static Rigidity.	Load, (lbs.)
			Length.	Temp.	Mo. of Inertia.	Time of Oscillation.			Length.	Temp.	Torque.	360°.	180°.	90°.	90°.	
						360°.	180°.	90°.			90°.					
Jan.	27	.356	42.11	14.8	14.75	15.10	14.76	14.53	42.14	14.5	.00891	176	185	191	152	5.422
"	30	.357	42.20	18.5	14.75	15.20	14.91	14.63	42.21	18.5	.00845	172	179	186	142	"
"	31	.360	41.41	15.4	13.21	14.29	14.03	13.79	41.43	15.4	.00917	166	173	179	147	4.869
Feb.	1	.366	40.50	18.5	11.74	13.16	12.93	12.68	40.51	18.5	.00929	159	165	171	136	4.322
"	2	.370	39.69	19.0	10.30	12.09	11.92	11.51	39.71	19.0	.00941	155	160	171	129	3.791
"	3	.373	38.95	14.0	8.83	10.93	10.67	10.30	38.97	14.0	.00979	155	163	175	128	3.249
"	5	.377	38.20	13.0	7.37	9.80	9.35	8.90	38.20	13.0	.00998	151	165	183	122	2.711
"	6	.382	37.44	18.6	5.90	8.52	8.32	7.74	37.44	18.6	.01090	148	156	180	124	2.183
"	7	.385	36.76	19.0	4.42	7.10	6.82	6.33	36.76	19.0	.01166	153	165	191	127	1.644
"	8	.390	36.09	15.4	2.88	5.65	5.19	4.65	36.09	15.4	.01323	146	174	217	134	1.089
"	9	.395	35.34	17.0	1.44	3.90	3.57	3.16	35.31	17.0	.01418	143	172	218	134	.561

Table III gives the results of the observations. There is a greater uniformity in the way in which the values of the rigidity vary with change of tension than there was when the tension was increasing, which may be ascribed in part to the somewhat greater uniformity of the time intervals between changing the load and determining the rigidity, and in part to a greater permanence of internal structure produced by the previous prolonged extension. It will be noticed (1) that the values of the rigidity run through pretty much the same course as they did in Table II, when the tension was being increased, though the final values of Table III, in the case of the static rigidity for the greater angle of torsion and in the case of the kinetic rigidity for the greater angles of oscillation, are less than the initial values of Table II, and (2) that the minimum point is given not only by the kinetic results for the amplitudes 180° and 90°, but also by the static results, which shows that the occurrence of the minimum point is not due to a defect peculiar to the kinetic method.

To see what effect the time interval between the putting on of the load and the finding of the rigidity, had on the rigidity, a new cord was experimented with in the following manner:—A weight having been put on the cord, the rigidity was determined both immediately afterwards and after the lapse of certain intervals of time. Then another weight was added and the previous process repeated. Owing to lack of time, only the kinetic method was used. Table IV gives the results.

TABLE IV.

DATE.	Temp.	Diam.	Mo of Inertia.	Length.	Time of Oscillation.			Kinetic Rigidity.			Load. (lbs)
					90°.	180°.	360°.	90°.	180°.	360°.	
February 1....	19.0	.382	3.08	36.81	5.31	5.66	5.80	197	173	165	1.133
" 2....	19.0	.381	3 08	36 92	4.85	5 32	5 75	239	199	170	"
" 2....	19.5	.374	5.99	38.12	7.80	8.17	8.42	200	182	171	2.206
" 3....	14.0	.374	5.99	38.25	7.16	7.70	8.27	238	206	178	"
" 5....	13.0	.373	5 99	38.33	7.28	7.92	8.36	233	197	177	"
" 6....	18.6	.374	5.99	38.38	7.45	8 08	8.57	220	187	167	"
" 7....	19.0	.374	5.99	38.40	7.20	8.00	8.50	236	191	169	"
" 7....	19.0	.368	8.92	39.72	10 45	10.73	11.03	184	175	165	3.272
" 8....	16.7	.366	8.92	39.90	10.01	10.58	10.93	206	184	173	"
" 9 ...	17.0	.366	8.92	39.95	10.03	10.48	10.93	205	188	173	"
" 10....	14.4	.366	8.92	40.01	9.65	10 33	10.96	222	194	172	"

It appears from these results that increase of tension in a cord which has been under tension for some time immediately decreases the rigidity, but that if the cord is left under the tension the rigidity increases again. According to the longest series of observations made, the rigidity of a cord thus left under a constant load seems to pass through a maximum point, but that is perhaps doubtful.

Since the immediate effect of increase of tension is to decrease the rigidity, it might be expected that the twisting of the cord in the determination of its rigidity would increase the rigidity, and that consequently the greater the angle the cord is twisted through the smaller will be the value of the rigidity found. This expectation is borne out by the results as given in the tables. It was also noticed when taking several observations of the time of oscillation in order to get a mean value, that the first values were always the smallest, a fact which seems to indicate that the rigidity decreases with strain.

From the preceding it is easily seen that the procedure followed above was not such as could give a simple relation between the observed rigidity and the tension. For since the rigidity of a cord under tension varies with time, the experiments must always be made, if they are to give a definite result, when the rigidity is at a minimum or a maximum. Now the minimum value of the rigidity of a cord under tension appears from the last table to be immediately after the tension is applied. If, however, we decide to determine the rigidity when at its minimum, not only must the rigidity be found immediately after the tension is applied, but the rigidity of the cord due to its previous tension must not have had time to change from the minimum value. Hence the procedure should be as follows: Load the cord and find the rigidity immediately, then increase the load and find the rigidity immediately, and so on, the whole series of experiments being carried out in the shortest time possible.

With a new cord of the same kind as before, this procedure was followed, and the results of Table V obtained.

TABLE V.

Date.	Temp.	Diam.	Length.	Mo. of Inertia.	Time of Oscillation.			Torque.	Kinetic Rigidity.			Static Rig.	Load, (lbs.)
					90°.	180°.	360°.	90°.	90°.	180°.	360°.	90°.	
Feb. 10	14.6	.372	34.58	1.44	4.25	4.41	4.50	.00851	150	139	135	100	.561
"	14.6	.368	35.39	2.88	6.18	6.32	6.47	.00827	151	144	139	103	1.080
"	14.4	.363	36.34	4.42	7.91	8.15	8.32	.00745	154	145	139	101	1.644
"	14.7	.357	37.45	5.90	9.52	9.75	10.03	.00715	156	149	140	107	2.183
"	15.0	.351	38.72	7.37	11.06	11.26	11.55	.00687	160	155	147	114	2.711
"	16.0	.345	40.03	8.83	12.53	12.78	13.18	.00636	166	159	150	117	3.249
"	16.7	.339	41.44	10.30	14.13	14.40	14.60	....	169	162	158	....	3.791

There is some lack of regularity in the results of this table so far as the determinations with smaller loads are concerned, but the divergence from regularity is probably within the limit of error of the observations. The results obtained with the larger loads exhibit much greater regularity than the results of the previous series of observations. The table shows that if the tension be increased as rapidly as is consistent with the determination of the rigidity at successive stages, the rigidity increases with the tension continuously, at first comparatively slowly, and finally with greater rapidity.

The comparatively slow increment of the rigidity under the smaller loads would suggest the possibility that the rigidity may not appreciably vary with the tension at all under the circumstances aimed at in the experiments. For in the light of the results of Table IV the larger values of the rigidity under the greater loads may be due entirely to the time effect of the previous increments of load.

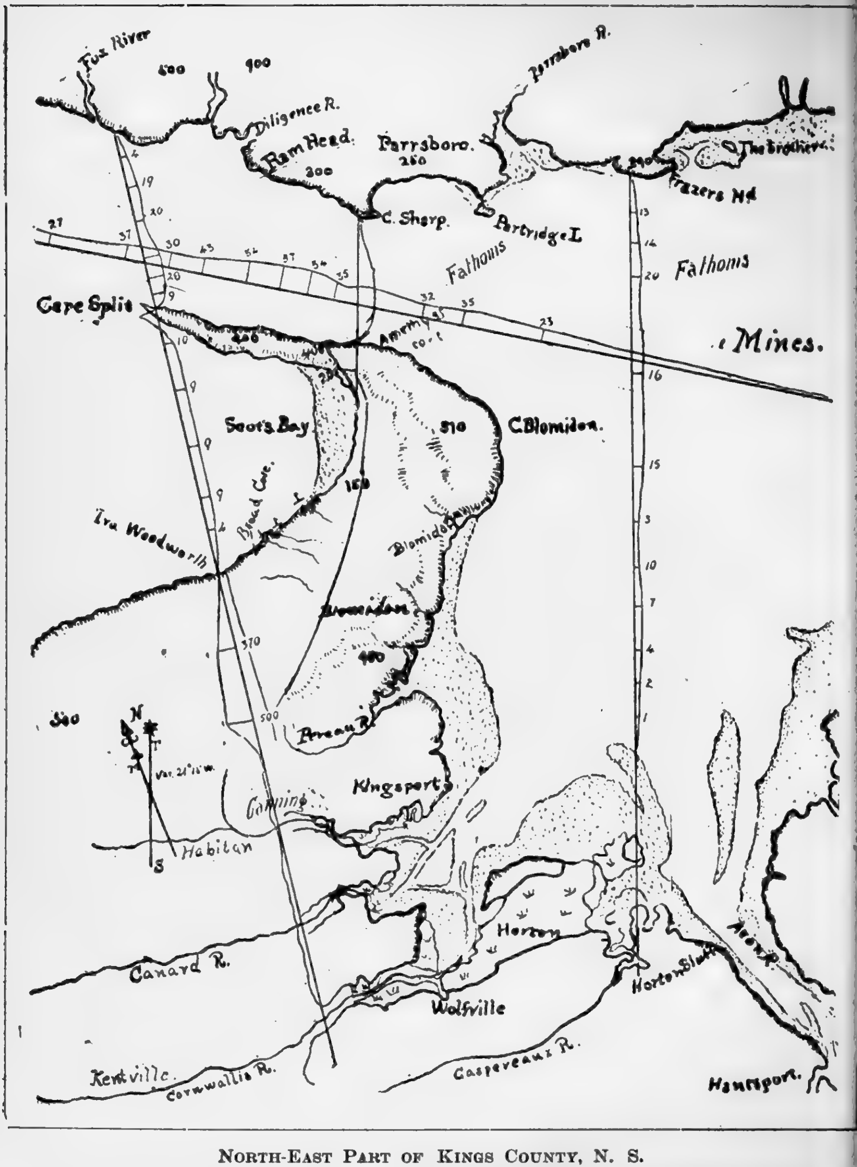
XII.—Records of Post-Triassic Changes in Kings County, N. S.—By Prof. E. Haycock, *Acadia College, Wolfville, N. S.*

(Read 9th April, 1900.)

It was my privilege last Autumn to make a hasty survey of that part of Kings County lying north of Canning, including Cape Blomidon. Several interesting problems were suggested during this trip, which I hope to follow up in the future.

I had in view two definite aims in visiting this region. The first was to look for the contact of the basaltic trap of the North Mountain with the underlying north-westerly dipping sandstone, and I hoped to find this contact laid bare and accessible to observation in the natural cross section formed by the line of cliffs which extends westwardly from Cape Blomidon to Cape Split. This line of cliffs was carefully examined from Amethyst Cove, where the trap extends beneath the sea, eastward to Cape Blomidon where red sandstone cut into many fantastic shapes by wind and water rises nearly two hundred feet and is surmounted by a sheet of black basaltic trap some two hundred feet in thickness ending abruptly in vertical cliffs behind and above the towers and bastions of the sandstone. Although the place where the contact of the two formations reaches the beach is easily determinable, and is marked by a long sloping line of springs, the talus of loose blocks and debris from the trap above is so great that at no point was the actual contact visible or accessible, so that the problem to be settled, whether the trap was poured out on a smooth sea bottom or on an old eroded land surface, remained undetermined.

The second object of the trip was to examine the coast section south-west from Scot's Bay. In the Transactions of the Institute for 1893-94, (Volume VIII., pp. 416, 419,) Mr. R. W. Ells mentions the occurrence, in this vicinity, of a calcareous



North-East Part of Kings County, N. S.
Scale: About four miles to one inch. Vertical scale 2400 feet to one inch. Depth of water in fathoms.—*For* Mines, *read:* Basin of Mines.

sedimentary formation overlying the trap of the North Mountain which was hurriedly observed by him in 1876. He states that no fossils had been found in these rocks, but concludes from the superposition of this formation on the trap that it is of more recent date. He does not hint at its probable age further than the above, but remarks that Prof. Bailey has reported rocks of somewhat similar nature in association with the trap of Digby Neck. Having been unable to find the statement in any of Prof. Bailey's writings accessible to me I made inquiry of him and found that he did not know of such a formation, or of having made the statement ascribed to him. This being the state of knowledge in regard to these rocks I hoped to find something that would throw light upon their age and possibly reveal a part of the geological history of this region during that long period so blank in records in Eastern Canada and New England, from early Mesozoic to the Glacial period.

In pursuit of this purpose I examined the shore south-west from Scot's Bay and was pleased to find for about four miles occasional good exposures in the coves of the formation mentioned by Dr. Ells, until Ira Woodworth Bay was reached. This is the exposure mentioned by him and was the most westerly outcrop seen. Beyond this according to local authority none of the rocks mentioned are found. Considerable value can be ascribed to the local accounts in this case owing to the search for amethysts which occur in cavities of masses of red jasper in some of the layers of limestone, and are collected by the inhabitants to supply the tourist trade. Only a hurried survey was made on this occasion and but one fossil was found, which, tho' poorly preserved, was plainly the coiled shell of a gastropod. The general appearance of the strata, however, led me to hope that better results would repay a careful and systematic search.

On November 6th, I left Wolville for a further study of this interesting formation. The results of my observations on this trip I will endeavor to put before you.

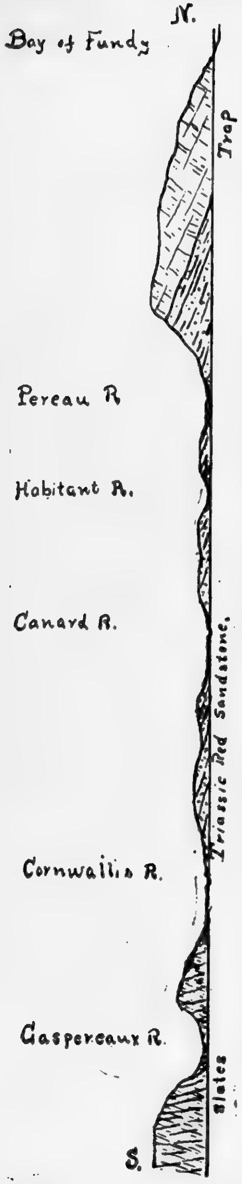


Diagram 1.—Section, Bay of Fundy to Gaspereaux R. Horizontal scale 3 miles to 1 inch. Vertical scale 1600 feet to 1 inch.

The general topography of the region alluded to is probably familiar to you all, as well as the common explanation of the geological structure, which appears to be, in the main, correct. From the parallel east-north-east and west-south-west ridges of slate and sandstone of later Palæozoic age, which extend along the south-east side of the Cornwallis Valley, a slightly undulating rich farming country stretches away to the north-west for some ten miles to the abrupt escarpment bounding the valley on its opposite side. The principal topographic features of this beautiful valley are three low ridges parallel in general trend with the older hills before mentioned and separated from each other and from the bounding ridges by long tongues of fertile dyked marsh in the basins of the Cornwallis, Canard, Habitant, and Pereau rivers. The existence of these ridges seems to be due to the occurrence of coarser harder groups of strata in the underlying red sandstone which dips with considerable uniformity and regularity to the north-west at angles of from eight to ten degrees. The ridges correspond with the strike of the formation and the valley topography is apparently one of erosion. The wearing out of the valleys took place when the country stood at a higher level, and the marsh deposits of

recent times now extend for several miles up the drowned valleys. That this topography is probably Pre-glacial is indicated by the occurence of a layer of Boulder clay of variable thickness mantling both hill and valley. The changes in topography since the disappearance of the ice of the Glacial period are exceedingly slight in this region and are confined almost wholly to the deposition, during a subsequent slight submergence, of some banks of stratified sand and gravel, some wearing away and retreat of the coast cliffs, and the filling-in of the river basins mentioned.

The North Mountain has the prevailing trend of the other ridges, and would appear to owe its present elevation above the valley to the harder and more resistant character of the sheet of volcanic rock, which protects the underlying soft sandstone from the action of the eroding agents that have worked with such effect upon the unprotected sandstone to the south-east. The junction of the sandstone and trap is some two hundred feet or more above the floor of the valley, and the conviction is forced upon the observer, when looking south-eastward from this point that not only the smaller valleys mentioned but also the whole broad depression he has crossed has been worn out of the soft red sandstone, and that excepting minor inequalities of surface the present relief of this part of the Province is wholly due to differential resistance of the underlying rocks.

The trap sheet retreats more rapidly along its edges than the sandstone owing to frostwork and its vertical jointing, and when they both appear in the face of the escarpment the overlying trap is never overhanging but always well behind the sandstone which generally forms a steep slope upon which the fragments of the trap are precipitated, forming broken masses which conceal the contact of the two formations. Because of the soft nature of the sandstone and its calcareous cement it weathers much more rapidly than the trap wherever exposed to the action of rain and wind, but since the jointing is not well developed it is not affected to a very great extent by the action of the frost.

From the top of the divide, which is near the edge of the escarpment, the surface slopes away to the north-west at angles of from eight to ten degrees. This is about the inclination of the beds of trap rock, and the present surface therefore corresponds in general inclination with the original surface of the formation. This ridge is cut by transverse valleys, the bottoms occupied by small brooks which seem altogether too small to have excavated the trenches they now occupy. A bank of boulder clay containing glaciated pebbles was seen resting in the bottom of a ravine on the floor of trap rock over which one of the larger brooks is now flowing. If these depressions were filled with the boulder clay of the Glacial period, the work since that time has been wholly expended in clearing out their ancient channels and the brooks have but just begun to renew their excavation on the Trap rock.

The four miles of coast examined form the south-east shore of Scot's Bay, and from Ira Woodworth Bay, Cape Split, the terminating point of the huge wall of rock forming the opposite side of Scot's Bay, bears nearly north. At this point the shore swings from south-west to about west-south-west which is the general trend of the coast for some sixty or seventy miles. With the exception of the Amygdaloidal character of the Trap, the shore below high water mark is not unlike many other portions of this Bay of Fundy coast. Beachy coves are more common because of the relatively sheltered position, but between these the black rough rocks slope seaward in sheets and reefs with very few outlying rocks and ledges. The sea at high tide washes the bases of a line of low cliffs some twenty to forty feet high, except in the deeper coves, where a narrow strip of gravel beach is left uncovered by all but the highest tides. Several brooks empty in small coves within the area examined and in their beds the extent of the shore formations landward can be traced.

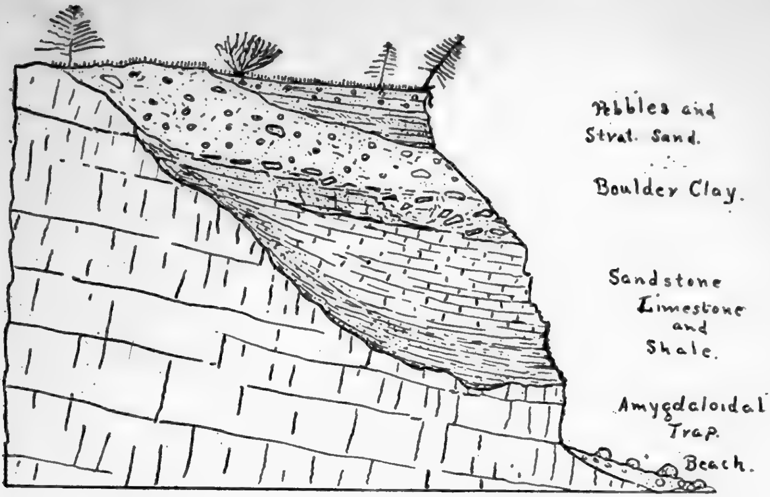


Diagram 2.—Section in Ira Woodworth Bay.

In the shore cliffs four distinct formations are revealed and in the ascending order they occur as follows :—

1. Trap Rock.

2. Sandstone and Impure limestone, 20-30 feet.

3. Boulder clay with striated stones in irregular masses, 20-30 feet.

4. Stratified sand and gravel 4 to 6 feet in thickness about thirty feet above high water mark.

Trap Rock.

The Basaltic Trap is, in this locality mainly amygdaloidal and occurs in sheets varying from two or three to many feet in thickness. The strike corresponds to the general trend of the shore. In many places the beds are intersected by a network of shrinkage cracks which have been subsequently filled with a dark reddish brown jasper. This is more resistant than the trap and the veins form a network of intersecting ridges separating saucer shaped depressions a foot or more in diameter. As the Trap approaches its contact with the limestone it becomes

more and more decayed until at the contact the rock is so loose and unconsolidated that it will scarcely hold together to form a hand specimen.

Sandstone and Impure Limestone.

The lower layers of the calcareous formation are largely made up of this disintegrated material but it is not found more than two or three feet from the contact. These lower layers are poorly defined and conform to the minor inequalities of the eroded surface of the Trap. The Trap debris then gives place to a fine grained light grey to green sandstone with calcareous cement, in thin laminae, which is overlain by beds of impure limestone from one to three feet thick alternating with thinner layers containing flint-like quartz bands. At one spot in Broad Cove a brown sandstone in beds three or four feet in thickness is seen overlying the limestone. The maximum thickness of this sedimentary formation would be about twenty-five feet. Altho several brooks cut across these beds at right angles, in only one can the limestone be traced, and there for a distance of but twenty or thirty yards from the beach where the trap appears in the bed. The other brooks have cut completely through and flow over the underlying trap until the beach is reached. This shows how little remains of what must have been an extensive formation and explains in part why it remained so long unnoticed.

The dip of these beds is, at first, somewhat confusing. On the north-east sides of the coves it is always to the south-west, and at angles as high as twenty degrees. On the south-west sides of the coves it is correspondingly high to the north-east. In the bed of the brook mentioned, which is in the centre of one of the coves, the dip proved to be from three to five degrees to the north-west. At several places the trap was visible beneath the apparent synclines and showed no corresponding deformation. Moreover, the variable inclination of the layers was there seen to be that of the contact surface of the trap on which they rest. As the layers recede from this surface they become more uniform in inclination which is seen to be to the north-west at an angle

FIG. 1.

BROAD COVE, LOOKING EAST, SHOWING LIMESTONE AND SHALE RESTING ON AMYGDALOIDAL TRAP.

FIG. 2. — UNCONFORMABLE CONTACT OF GREENISH SHALE WITH AMYGDALOIDAL TRAP IN BROAD COVE.

To face page 294.

slightly smaller than that of the trap, or the same as the observation taken in the brook.

In some of the lower fine grained calcareous shales sun cracks frequently occur and together with trail-like markings and carbonaceeus impressions of branching fucoid-like plants point to shallow water or tidal conditions prevailing during the deposition of the lowest layers. The fineness of the material of these lowest layers also indicates a very gradual quiet submergence of the disintegrated Trap rock and the absence of heavy waves upon the subsiding beaches. The heavier bedded limestone is quite free from inorganic sediment, and is a deposit in deeper and purer water. The heavy bedded brown sandstone marks some change bringing about a great increase of inorganic sediment. Whether it was a re-elevation bringing the area nearer shore, or advent of currents carrying such sediment is at present undetermined.

Fossils occur in the underlying shale and limestone, altho' they are, as a rule, poorly preserved. Among those collected are fish scales and teeth, objects resembling the seed cones of gymnosperms, marine fucoids, and long, tapering, generally straight, objects that are thought to be the shells of cephalopods. These occur in the limestone and calcareous sandstone often in great profusion and may reach a length of eight or ten feet, and a diameter at the larger end of eight or nine inches. The smaller ends are rounded, and usually about one, though sometimes two or three, inches in diameter. They are cylindrically or longitudinally knobbed, hollow in the centre, and composed mainly of a red jasper. That these forms are of organic origin and are not concretions is indicated by their similarity in form and by their lying, in one bed, in such numbers that they cross each other in every conceivable way, but always the characteristic form of each individual can be determined. In all cases the finer laminæ of the beds are pressed down beneath by the weight of the object, and those deposited after curve up over it without interruption. Other forms occur here also. One cf these was twenty-seven inches in diameter and appeared cup-like in shape.

It has been stated that these strata rest unconformably on a surface of decomposed trap, and that the lower layers are made up, in part, of the triturated fragments of the trap. This would indicate that after the pouring out of these lava sheets their surface was above water, was carved into valleys and hills, by the streams of the time, and subjected to the decomposing action of atmospheric agencies and vegetation, until the ancient surface came to present the irregular and weathered aspect that we may now see on portions that have been subjected to similar action during recent geological time. This necessarily long exposure preceded the subsidence and submergence during which the stratified formation was deposited and would indicate, to my mind, that at least a whole geological period had intervened between the outpouring of the trap and the deposition of the marine formation unconformably upon its weathered surface. The trap is considered to be of Triassic age and I would place that of the limestone as probably Cretaceous. Again, from Cape Cod southwards marine deposits were laid down along the Atlantic border during Cretaceous times. Altho' I have as yet been unable to find any traces of foraminifera in the soft greenish sandstone that occurs in one of the coves, yet the general aspect of the fossils so far found is also suggestive of Cretaceous age.

The hollows or depressions in which these remnants are preserved are at present small valleys, occupied by brooks and terminating on the shore in small coves which also owe their existence to the erosion preceding the deposition of this formation. The Topography of this portion of the North Mountain is thus shown to be much older than the Glacial period and not only are the brooks flowing in Mesozoic channels but the Bay of Fundy waves are again washing the shores of coves from which they have been excluded since the Mesozoic period.

The facts observed here are in accord with the conclusion arrived at from a comparison of the present stream beds with the streams that now occupy them. Some of the gorges in this area are equal in magnitude to those of the secondary streams of the South Mountain, although the volume of water now flow-

ing in them is insignificant. The cross trenches in this particular locality are, however, small as compared with those that cross the mountain at intervals of a few miles throughout its length, some of which are scarcely above sea level, others as Digby Gut and Petite Passage 150 to 200 feet below.

These deep gorges are probably Pre-glacial, as well, since they are partly filled with boulder clay and usually, if not always, set opposite to corresponding depressions in the older hills on the opposite side of the valley. The ice of the Glacial epoch flowed over ridge and through hollow alike, and beyond sweeping away the decayed and shattered layer down to the undecomposed rock seems to have had little effect in transforming the general topography of the country. These gorges then are doubtless Pre-glacial, but how much older? Though much larger they are of the same character as the smaller hollows filled with the sedimentary limestone, and are probably of the same, or Mesozoic age. Although direct evidence of this has not yet been obtained it may exist, only awaiting the coming of a careful observer.

The most significant features of these greater gorges is their positions, just mentioned, nearly opposite to corresponding river gorges on the south-east side of the valley. Almost every deep gorge in the North Mountain has its corresponding river valley in the higher ground of the South Mountain opposite. The depressions reaching the Bay of Fundy coast at Parker's Cove, Digby Gut, Sandy Cove, opposite the Lequille, Bear, and Weymouth rivers are striking examples. A possible if not the only plausible explanation of this fact, taken in connection with the evidence of the great age of these depressions, is that they are respectively the old outlets of Mesozoic rivers that flowed northwestwardly across the sandstone and its overlying trap sheet, draining a country more extensive than the present Nova Scotia, because of its greater elevation, and with their greater volume wearing broad channels through the red sandstone but abrupt and precipitous trenches in the trap. The effect would be the same in the basins of the smaller streams such as those now

heading back to a low divide some three or four miles from the coast.

During the submergence of the region in late Mesozoic or early Tertiary times, the streams were drowned by the sea and the silicious and calcareous deposits described were laid down in the old river valleys. Deposits forming in this way would be protected from the disturbances of the open shore, and probably be composed of fine sediment laid bare at each low tide and dried and sun cracked in bright warm days until carried below the tidal limits by the slow subsidence of the whole region. The limestone deposits indicate a submergence great enough to have formed large inland basins in the broad valleys in the sandstone country south-east of the edge of the trap sheet. These were possibly separated from each other by low divides which would be gradually lessened by the rapid vertical decay of this rock referred to earlier in this paper. When once covered by the sea, the swiftly moving north-east and south-west tidal currents characteristic of this region would scour out the valley at a rapid rate, while the trap sheet would not retreat along its edges at a corresponding rate since the frost work had not yet been inaugurated, mild and warm climates extending at this time even within the Arctic Circle. On the re-elevation of the country in middle or late Tertiary times, the rivers would not return to their ancient channels across the trap which were now higher than the valley floor and filled in with deposits of the kind described, but would flow along the valley parallel with the mountain in either direction only discharging at the lowest outlets as Digby Gut at the south-west and Minas Basin and Channel at the north-east.

The colder climates of late Tertiary times were now setting in with winter frosts and snow, and the sheet of trap would begin the rapid horizontal retreat which has continued until the present day.

Boulder Clay.

Boulder clay containing many striated stones from local sources occurs throughout this whole region and is seldom absent

except from the loftier and more exposed portions of the ridges. The prevalence of compact and amygdaloidal trap from the North Mountain in the Boulder clay all over the south side of the valley, as well as the rounded and worn north facing slopes of the elevations indicate that the general movement of the transporting agent was from the north. The general trend of all the striations I have yet seen in this vicinity is in the same direction.

Although Boulder clay is rarely seen along the exposed side of the North Mountain except when sheltered by the precipitous walls of the deep gorges which have been alluded to, on the stretch of shore south-east of Scot's Bay, deposits of considerable thickness rest alike on trap and limestone and contain striated fragments of both formations. In general the mass has the same decided red color as the sandstone cliffs underlying the trap at Cape Blomidon. One exception to this occurs in Ira Woodworth Bay where the underlying portion of this deposit is completely made up of a calcareous light grey clay mixed with angular, occasionally striated fragments of the sedimentary formation. It is wholly composed of the broken and pulverized layers of this sedimentary formation and passes up abruptly into the red clay and trap boulders among which no trace of limestone could be found.

The abundance of boulder clay on this strip of coast proves it to have been a region of deposit rather than of erosion during its burial beneath the ice of the Glacial Period. That deposition was not continuous is shown, however, by the occurrence of the debris of the adjacent calcareous strata at the most westerly point at which these strata were seen. Farther east the red deposits seemed to rest directly upon the light grey limestone and sandstone and these portions do not seem to have suffered as much from the grinding action of the ice sheet.

The evidence from striations and from travelled boulders prove that the general movement of this ice sheet was from the north. From Ira Woodworth Bay, Cape Split bears due north and from this bold Cape a line of vertical cliffs from two to four hundred feet in height extends eastward for eight miles to Cape

Blomidon, offering a huge barrier to the advancing ice sheet which would deflect the main current, and leave a sheltered area behind where the eroding action would be small or absent altogether, and the conditions favorable for deposition during the decline and disappearance of the ice.

This protected area would extend about to Ira Woodworth Bay, whence westwardly the shore would be exposed to the full sweep of the mass passing to the westward of Cape Split. It is significant that east of this Bay occur the heavy deposits of boulder clay while to the west a bold bare coast of black forbidding trap extends for a hundred and twenty miles with but an occasional heap of red boulder clay that has been deposited behind some projecting cliff. Have we not here a simple explanation of the preservation of this fragment of marine limestone, this mere remnant of what must have been a formation of considerable extent, the sole representative in north-eastern America, containing the only known records for that region, of the Geological history of the long period of time between the Triassic and the Glacial periods.

Stratified Sand and Gravel.

But the records preserved in this strip of coast do not end with those of the Glacial period. Overlying the boulder clay is a deposit of stratified sand and gravel several feet in thickness, the base of which is now some thirty feet above high tide level. The upper limit of this formation was not determined, but the coarse and water worn character of the material classes it as a shore deposit, laid down within or but slightly below tidal limits. This formation has been noticed at Wolfville, Pereau and at several localities in Digby County. In the Cornwallis Valley it consists mainly of stratified sands in which the cross bedding indicates that during their deposition the currents flowed strongly both to the north-east and to the south-west, or parallel with the general trend of the valley.

These deposits tell of a submergence succeeding the Glacial period of at least thirty or forty feet and a re-elevation of at

least the same magnitude. It is probable that during the deposition of these beds the waters of Minas Basin, Digby Basin and St. Mary's Bay were connected and that the present flat and fertile valley stretching from the base of the North Mountain to the low Palæozoic hills on the south was a shallow strait through which twice a day the ebb and flood swept swiftly planing down the valley to a uniform level but sweeping up here and there long bars of shifting sands. These still remain but form minor features in the topography of the valley.

This shallow strait was sheltered from the rougher waters of the Bay of Fundy by the protecting barrier of the North Mountain and the deposits in the valley are much finer than those of the same age on the Bay of Fundy coast. The North Mountain itself was cut up into a line of narrow islands by the submergence which brought the bottoms of several of the deeper gorges below sea level, and the old shore lines in some of these may still be seen. The length of the chain was practically the same as at present since Briar Island the westermost extension of the trap ridge then formed two small islands rising some fifty feet above the sea as shown by the old shore line about eighty feet above the present sea level.

When the land again arose, the waters left the valley, the rivers extended seaward removing the sand and gravel from their old channels, wearing them deeper, and the now submerged forests grew.

But again a gradual subsidence followed. The sea slowly advanced up the river channels. The fine sediment brought down by the rivers was arrested by the tidal currents and deposited in their shallow estuaries, and the marine marshes were formed.

This is as we find it at the present day. The changes are still in progress. The history of this region which we have followed from early Mesozoic times to the present, or as much of it as the records known to us reveal, is still being written in the changing surface features of the land, the retreating coast line, and the strata now forming off our shores. Every change,

no matter how small is thus recorded, and this account is merely an attempt to read aright such records as have come under the observation of the writer in a few hasty journeys among the newer formations of our Province.

Brief and limited as these opportunities for observation have been, they have convinced me that the field for Geological investigation, in this region at least, is ample; that it is wonderfully rich in undiscovered facts; and that for variety in lithological, in palaeontological and in structural features, it is unequalled by any area of similar extent in eastern North America. That such is the case is shown by the results achieved by Sir J. Wm. Dawson during the third quarter of the century and set forth by him so clearly and interestingly in his "Acadian Geology," a work which must ever remain for us a model of close observation, broad and scientific induction, and elegant expression.

Because of its exceptional richness, however, the field has not yet been exhausted, in the region of Minas Basin and westward the soil has merely been broken. The broader relations of the great formations to one another have been worked out and their relative age established, but in knowledge of their lithological composition, fossil contents, structural peculiarities, conditions of deposition, relation to present topographic features, etc., we are almost wholly deficient. The field is alluring and full of promise to the Geologist. Let us who are native born reap the rich harvest of facts before we are anticipated by workers from the over-crowded fields of New England.

XIII.—Phenological Observations, Canada, 1899, by A. H. MacKay, LL. D.

(*Read 9th April, 1900.*)

The schedule on which the observations referred to here were recorded specifies 100 different objects, some with subdivisions. Of the great majority of them, two classes of observations are asked to be recorded: "When first seen," and "When becoming common." In the tabulated dates recorded by the Botanical Club of Canada, given at the end of this paper, the first series only is taken. The character of the schedule is also indicated in these tables of observations at the thirteen stations throughout Canada.

The identical schedule is also used in the public schools of the Province of Nova Scotia. The observations here are made by the pupils in attendance as a part of their "nature study," when going to and returning from school, and are tested and recorded by the teacher in duplicate, one copy of which is preserved as a local record, and the other is sent with the school returns to the Inspector for the Education Office.

Seven hundred and twenty-five school sections (school districts, localities, or stations) returned schedules of observations, the majority more full than those of the thirteen stations of the Botanical Club reporting. The summation of these in tabular form would require a large volume, and cannot, therefore, be attempted here. The schedules are bound up in a volume for each year, so that the information may not only be preserved for the future use of students, but may be conveniently accessible. The series of volumes will be a mine of information bearing on at least one phase of the problem of secular variation of climate.

The same ten plants taken last year are here selected from the list of one hundred objects for the purpose of comparison

as to the average time of *first* flowering and when flowering was *beginning* to become common. In some counties the observations were so full that thirty good stations could be selected for averaging, ten from the *sea coast*, ten from *low inland* settlements, and ten from *high land* settlements. These average dates or phenochrons of flowering are arranged in parallel columns for the sake of comparison. In some counties only twenty satisfactory stations for averaging, and in others only ten, were found, as can be seen at a glance from the tabulation of the figures.

The average phenochron for each plant's *first* flowering and flowering *becoming common* is calculated for each county, and the mean of the two series is finally taken for comparison with the similar general phenochron for the same phenomenon in 1898. These general phenochrons are plotted on the accompanying diagram so as to show their curves through the counties of the Province arranged in a linear series beginning at the west and south, and proceeding to the east and north.

This order of the counties will be uniformly followed in future plottings of the phenochronic curves, for the greater ease of comparing those of one year with those of another. Last year the counties were arranged in the order of their most general phenochrons. Were the same rule followed this year the positions of some of the counties would be changed; but if the positions of the counties remain fixed the configurations of the phenochronic curves will illustrate the variations very clearly from year to year.

On a future occasion I propose to plot the phenochrons of the same phenomena running through the counties of the province for two or three consecutive years, in order to study the character of the annual observations, or the peculiarities of climate or flowering. Unfortunately, we cannot be sure of the degree of variation originating in the latter causes until we are sure of a uniform system of correct observations symmetrically distributed.

Apart from any generalization of value which may be expected from such work carried on continuously for years, it is found to be a valuable stimulus to the formation of habits of accurate observation in the pupils of the public schools, and to the study of nature on the road to and from school, when it does not interfere with any other study, and when it adds interest and often amusement to otherwise monotonous road travel. For this purpose alone the trifling cost of supplying the schedules are many thousands of times repaid.

The names of the *ten* plants whose average dates of flowering are given in the columns following, as described, cannot be given on the same page with their phenochrons without overcrowding. The names are, therefore, to be understood to be prefixed in the following order to each column :

1. The Mayflower *(Epigœa repens)*.
2. The Blue Violet *(Viola cucullata)*.
3. The Red Maple *(Acer rubrum)*.
4. The Dandelion *(Taraxacum officinale)*.
4. The Strawberry *(Fragaria Virginiana)*.
6. The Wild Red Cherry *(Prunus Pennsylvanicum)*.
7. The Tall Buttercup *(Ranunculus acris)*.
8. The Indian Pear *(Amelanchier Canadensis)*.
9. The Cultivated Apple *(Pyrus malus)*.
10. The Lilac *(Syringa vulgaris)*.

FLOWERING PHENOCHRONS

Of the foregoing ten Plants in the Eighteen Counties of Nova Scotia, for the year 1899.

YARMOUTH COUNTY, 1899.

First Seen.				Becoming Common.				General Phenochrons.	
Coast.	Low Inlands	High-lands.	Aver-age.	Coast.	Low Inlands.	High-lands.	Aver-age.	Annual date.	Mensual date.
98.2	87.8	.....	93.0	109.7	103.7	.....	106.7	99.85	10 April.
117.8	118.2	......	118.0	127.4	124.2	......	125.8	121.90	2 May.
125.2	129.2	. . .	127.2	130.5	134.2	......	132.3	129.77	10 "
117.4	119.7	.....	118.5	129.6	127.5	.....	128.5	123.55	4 "
118.3	115.6	......	116.9	131.8	125.8	.....	128.8	122.87	3 "
135.9	137.3	......	136.6	144.1	142.9	......	143.5	140.05	21 "
141.8	130.6	......	136.2	153.8	141.2	.. .	147.5	141.85	22 "
142.8	136.6	......	139.7	146.6	143.4	......	145.0	142.35	23 "
147.5	139.0	......	143.2	157.4	148.9	......	153.1	148.20	29 "
160.4	151.6	......	156.0	166.9	158.0	......	162.4	159.22	9 June.
130.53	126.56	.....	128.54	139.78	134.98	......	137.38	132.96	13 May.

SHELBURNE COUNTY, 1899.

First Seen.				Becoming Common.				General Phenochrons.	
Coast.	Low Inlands	High-lands.	Aver-age.	Coast.	Low Inlands.	High-lands.	Aver-age.	Annual date.	Mensual date.
99.9	101.2	.....	100.5	108.2	110.9	......	109.5	105.05	16 April.
122.0	121.0	......	121.5	129.5	127.0	......	128.2	124.87	5 May.
125.5	124.0	......	124.7	134.2	133.9	....	134.0	129.40	10 "
120.0	123.5	......	121.7	132.7	131.1	.....	131.9	126.82	7 "
121.8	121.9	......	121.8	133.2	130.1	.....	131.6	126.75	7 "
142.0	140.5	......	141.2	150.0	146.8	......	148.4	144.82	25 "
135.7	144.8	......	140.2	148.4	151.0	....	149.7	144.97	25 "
138.1	137.6	......	137.8	146.7	146.6	......	146.6	142.25	23 "
147.0	147.0	.....	147.0	155.1	155.4	.....	155.2	151.12	31 "
156.7	157.8	......	157.2	163.9	163.3	...	163.6	160.42	10 June.
130.87	131.93	....	131.40	140.19	139.61	......	139.90	135.65	16 May.

DIGBY COUNTY, 1899.

First Seen.				Becoming Common.				General Phenochrons.	
Coast.	Low Inlands	High-lands.	Aver-age.	Coast.	Low Inlands.	High-lands.	Aver-age.	Annual date.	Mensual date.
*	*			*	*				
102.4	102.6	104.1	103.0	110.6	117.4	122.0	116.6	109.86	20 April.
119.7	120.2	122.6	120.8	127.2	130.6	127.3	128.3	124.58	5 May.
130.4	133.4	126.2	130.	137.8	138.8	132.0	136.2	133.10	14 "
118.4	121.4	123.9	121.2	128.0	127.8	121.3	125.7	123.46	4 "
116.4	120.2	119.7	118.7	128.8	130.4	128.2	129.1	123.95	4 "
136.8	143.6	136.9	139.1	148.2	153.8	143.6	148.5	143.81	24 "
145.8	146.4	143.6	145.2	153.2	156.4	150.7	153.4	149.35	30 "
141.0	136.8	132.5	136.7	149.6	148.2	138.2	145.3	141.05	22 "
144.8	142.4	140.0	142.4	154.2	151.6	147.3	151.0	146.71	27 "
156.6	157.6	152.6	155.6	162.0	164.8	159.3	162.0	158.81	8 June.
131.24	132.46	130.21	131.20	139.96	141.98	136.99	139.64	135.47	16 May.

FLOWERING PHENOCHRONS—*Continued.*

QUEENS COUNTY, 1899.

First Seen.				Becoming Common.				General Phenochrons.	
Coast.	Low Inlands.	Highlands.	Average.	Coast.	Low Inlands.	Highlands.	Average.	Annual date.	Mensual date.
103.2	....	106.2	104.7	112.7	....	113.8	113.2	108.97	19 April.
124.2	....	121.4	122.8	131.5	....	127.4	129.4	126.12	7 May.
128.6	....	120.4	124.5	135.9	....	125.8	130.8	127.67	8 "
125.5	....	123.7	124.6	134.4	....	134.1	134.2	129.42	10 "
125.9	....	123.3	124.6	138.4	....	134.0	136.2	130.40	11 "
140.7	....	138.4	139.5	147.4	....	145.5	146.4	143.00	23 "
149.9	....	148.3	149.1	158.9	....	157.9	158.4	153.75	3 June.
136.2	....	133.0	134.6	145.2	....	137.2	141.2	137.90	18 May.
146.9	....	144.2	145.5	152.5	....	151.1	151.8	148.67	29 "
157.0	....	152.6	154.8	164.2	....	157.0	160.6	157.70	7 June.
133.81	....	131.15	132.48	142.11	....	138.38	140.24	136.36	17 May.

ANNAPOLIS COUNTY, 1899.

......	99.9	107.7	103.8	....	110.1	117.1	113.6	198.70	19 April.
......	124.7	126.0	125.3	......	132.2	133.1	132.6	129.00	9 May.
......	129.3	123.7	126.5	......	134.0	128.4	131.2	128.85	9 "
......	125.3	128.8	127.0	......	133.6	135.1	134.3	130.70	11 "
......	122.2	123.5	122.8	....	130.7	133.5	132.1	127.47	8 "
......	137.8	140.7	139.2	......	143.6	146.9	145.2	142.25	23 "
......	145.9	147.5	146.7	......	155.1	156.3	155.7	151.20	1 June.
......	133.4	136.0	134.7	......	137.5	141.2	139.3	137.02	18 May.
......	139.9	145.7	142.8	......	148.3	152.3	150.3	146.55	27 "
......	152.3	153.7	153.0	......	159.1	159.4	159.2	156.12	6 June.
......	131.07	133.33	132.20	......	138.42	140.33	139.37	135.78	16 May.

LUNENBURG COUNTY, 1899.

102.4	104.6	105.3	104.1	111.1	114.2	114.7	113.3	108.71	19 April.
123.5	123.9	122.8	123.4	130.4	129.9	129.6	129.9	126.68	7 May.
123.6	120.2	122.0	121.9	129.7	129.4	127.5	128.8	125.40	6 "
126.2	128.3	127.0	127.1	131.3	137.2	134.0	134.1	130.66	11 "
126.0	125.3	122.7	124.6	131.6	134.1	130.2	131.9	128.31	9 "
139.1	137.2	139.9	138.7	144.2	143.2	146.5	144.6	141.68	22 "
150.5	149.7	148.9	149.7	157.6	156.6	155.0	156.4	153.05	3 June.
142.0	130.5	132.0	134.8	148.6	139.4	138.2	142.0	138.45	19 May.
144.3	145.8	144.6	144.9	155.0	152.3	152.3	153.2	149.05	30 "
158.5	154.5	153.0	155.3	164.5	159.8	156.7	160.3	157.83	7 June.
133.61	132.00	131.82	132.47	140.40	139.61	138.47	139.49	135.98	16 May.

Flowering Phenochrons — *Continued.*

KINGS COUNTY, 1899.

First Seen.				Becoming Common.				General Phenochrons.	
Coast.	Low Inlands.	High-lands.	Aver-age.	Coast.	Low Inlands.	High-lands	Aver-age.	Annual date.	Mensual date.
......	103.8	109.9	106.8	......	114.8	118.6	116.7	111.77	22 April.
......	120.7	125.8	123.2	......	126.7	134.4	130.5	126.90	7 May.
......	124.1	125.6	124.8	......	132.3	133.0	132.6	128.75	9 "
......	123.6	127.5	125.5	......	133.6	135.8	134.7	130.12	11 "
......	122.5	123.5	123.0	......	133.5	131.7	132.6	127.80	8 "
......	142.0	141.5	141.7	......	150.2	146.3	148.2	145.00	25 "
......	140.2	152.7	146.4	......	153.8	157.9	155.8.	151.15	1 June.
......	136.2	134.7	135.4	......	144.0	140.7	142.3	138.90	19 May.
......	141.6	145.8	143.7	......	152.6	152.4	152.5	148.10	29 "
......	152.9	154.6	153.7	......	159.1	161.3	160.2	156.97	6 June.
....	130.76	134.16	132.46	......	140.06	141.21	140.63	136.54	17 May.

HANTS COUNTY, 1899.

Coast.	Low Inlands.	High-lands.	Aver-age.	Coast.	Low Inlands.	High-lands	Aver-age.	Annual date.	Mensual date.
......	103.8	109.3	106.5	......	114.9	119.1	117.0	111.77	22 April.
......	123.8	127.8	125.8	......	129.4	134.8	132.1	128.95	9 May.
......	126.6	126.9	126.7	......	131.0	131.8	131.4	129.07	10 "
......	125.2	129.6	127.4	......	134.3	136.7	135.5	131.45	12 "
......	123.2	126.6	124.9	......	134.7	132.7	133.7	129.30	10 "
......	138.6	146.2	142.4	......	147.2	151.3	149.2	145.82	26 "
......	141.3	153.3	147.3	......	154.6	159.7	157.1	152.22	2 June.
......	135.6	144.0	139.8	......	142.6	149.5	146.0	142.92	23 May.
......	144.7	150.8	147.7	......	151.1	157.5	154.3	151.02	1 June.
......	153.1	156.9	155.0	......	160.6	163.7	162.1	158.57	8 "
......	131.59	137.14	134.36	......	140.04	143.68	141.86	138.11	19 May.

HALIFAX COUNTY. 1899.

Coast.	Low Inlands.	High-lands.	Aver-age.	Coast.	Low Inlands.	High-lands	Aver-age.	Annual date.	Mensual date.
104.6	105.9	108.2	106.2	119.2	114.9	118.8	117.6	111.93	22 April.
123.3	123.9	128.7	125.3	132.2	130.1	136.7	133.0	129.15	10 May.
124.6	126.3	122.7	124.5	132.7	133.9	133.0	133.2	128.86	9 "
126.3	127.5	130.1	127.9	135.9	134.4	138.6	136.3	132.13	13 "
126.9	124.0	125.8	125.5	137.1	135.3	135.5	135.9	130.76	11 "
144.1	144.1	142.6	143.6	152.9	150.1	147.3	150.1	146.85	27 "
151.8	149.6	150.0	150.4	161.5	157.2	161.0	159.9	155.18	5 June.
143.5	138.1	138.1	139.9	150.7	145.5	145.6	147.2	143.58	24 May.
154.5	148.3	151.1	151.3	164.1	156.8	157.5	159.4	155.38	5 June.
167.7	158.0	156.9	160.8	175.6	164.6	162.7	167.6	164.25	14 "
136.73	134.57	135.42	135.57	146.19	142.28	143.67	144.04	139.81	20 May.

Flowering Phenochrons — *Continued.*

GUYSBORO COUNTY, 1899.

First Seen.				Becoming Common.				General Phenochrons.	
Coast.	Low Inland.	High-lands.	Aver-age.	Coast.	Low Inland.	High-lands.	Aver-age.	Annual date.	Mensual date.
......	....	.....	113.8	.....	....	......	122.4	118.10	29 April.
......	....	.....	129.7	......	....	.....	135.2	132.45	13 May.
......	....	....	123.7	......	....	....	131.3	127.50	8 "
......	....	....	135.7	......	....	.....	141.8	138.75	19 "
.....	....	......	132.9	.....	....	....	144.4	138.65	19 "
......	....	......	148.6	......	....	......	153.2	150.90	31 "
......	....	......	159.7	......	....	....	165.0	162.35	12 June.
....	....	......	145.4	......	....	....	150.8	148.10	29 May.
......	....		156.5	......	....	.....	162.3	159.40	9 June.
....	....	....	164.7	....	....	....	169.0	166.85	16 "
. . .	....	.. ..	141.07	......	....	.. ..	147.54	144.30	25 May.

CUMBERLAND COUNTY, 1899.

Coast.	Low Inland.	High-lands.	Aver-age.	Coast.	Low Inland.	High-lands.	Aver-age.	Annual date.	Mensual date.
116.7	111.9	110.7	113.1	123.5	121.7	118.5	121.2	117.16	28 April.
124.8	127.3	127.5	126.5	131.2	136.0	134.4	133.8	130.20	11 May.
127.4	126.8	123.1	125.7	134.6	132.7	130.9	132.7	129.25	10 "
131.4	130.2	128.8	130.1	137.6	139.7	136.0	137.7	133.95	14 "
126.8	129.0	123.7	126.5	134.3	141.3	134.7	136.7	131.63	12 "
145.9	141.1	140.4	142.4	151.2	146.9	146.4	148.1	145.21	26 "
154.7	149.1	150.3	151.3	160.3	159.5	155.8	158.5	154.95	4 June.
141.0	137.4	135.5	137.9	147.1	145.3	142.7	145.0	141.50	22 May.
152.4	149.3	149.5	150.4	158.6	154.3	155.7	156.2	153.30	3 June.
156 5	155.2	155.5	155.7	162.6	161.5	161.2	161.7	158.75	8 "
137.76	135.73	134.50	135.99	144.10	143.89	141.63	143.20	139.60	20 May.

COLCHESTER COUNTY, 1899.

Coast.	Low Inland.	High-lands.	Aver-age.	Coast.	Low Inland.	High-lands.	Aver-age.	Annual date.	Mensual date.
106.1	112.2	118.9	112.4	118.1	117.6	125.4	120.3	116.38	27 April.
124.4	126.3	127.3	126.0	132.9	132.6	134.2	133.2	129.61	10 May.
129.5	127.9	128.9	128.7	135.3	132.5	134.6	134.1	131.45	12 "
128.4	129.7	128.9	129.0	137.2	136.3	136.6	136.7	132.85	13 "
126.8	126.5	126.0	126.4	134.7	136.2	135.0	135.3	130.86	11 "
141.3	140.3	147.4	143.0	147.3	147.8	152.4	149.1	146.08	27 "
149.3	148.6	149.5	149.1	157.5	156.7	156.1	156.7	152.95	2 June.
141.2	138.4	141.2	140.2	147.1	143.7	148.7	146.5	143.38	24 May.
148.1	146.5	152.0	148.8	155.5	154.6	158.5	156.2	152.53	2 June.
156.5	157.4	160.8	158.2	163.4	162.3	166.8	164.1	161.20	11 "
135.16	135.38	138.09	136.21	142.90	142.03	144.83	143.25	139.73	20 May.

FLOWERING PHENOCHRONS – *Continued.*

PICTOU COUNTY, 1899.

First Seen.				Becoming Common.				General Phenochrons.	
Coast.	Low Inland.	High-lands.	Aver-age.	Coast.	Low Inlands.	High-lands.	Aver-age.	Annual date.	Mensual date.
107.4	111.8	112.2	110.4	118.0	122.5	119.2	119.9	115.18	26 April.
126.4	127.1	127.1	126.8	134.4	134.8	134.8	134.6	130.76	11 May.
126.7	123.3	126.2	125.4	133.0	130.1	131.9	131.6	128.53	9 "
127.3	128.6	130.4	128.7	134.5	135.5	137.2	135.7	132.25	13 "
128.8	126.2	126.7	127.2	135.8	136 8	137.2	136.6	131.91	12 "
148.5	144.6	145.9	146.3	152.8	149.7	151.0	151.1	148.75	29 "
148.8	148.7	150.0	149.1	155.7	155.9	156.4	156.0	152.58	2 June.
142.0	141.3	140.9	141.4	147.4	145.4	145.3	146.0	143.71	24 May.
150.9	146.7	149.4	149.0	156.1	153.5	156.3	155.3	152.15	2 June.
156.1	156.2	157.2	156.5	161.3	160.9	162.7	161.6	159.06	9 "
136.29	135.45	136.60	136.11	142.90	142.51	143.20	142.87	139.49	20 May.

ANTIGONISH COUNTY, 1899.

....	....	......	117.4	....	....	......	125.9	121.65	2 May.
......	....	......	127.6	......	....	.....	134.6	131.10	12 "
......	......	.....	132.8	.....	....	.. .	136.6	134.70	15 "
. ....	....	......	130.1	......	....	......	136.8	133.45	14 "
.....	....	......	128.2	.. ...	....	.....	139.9	134.05	15 "
....	....	......	146.9	......	....	......	153.4	150.15	31 "
......	....	......	153.8	......	....	......	161.0	157.40	7 June.
......	....	......	145.4	......	....	......	151.2	148.30	29 May.
......	....	... .	152.9	......	....	......	158.1	155.50	5 June.
......	....	.. ...	160.4	......	....	.....	165.8	163.10	13 "
....	....	.....	139.55	......	....	......	146.33	142.94	23 May.

RICHMOND COUNTY 1899.

.....	....	......	110.7	......	....	......	121.5	116.10	27 April.
......	....	......	129.9	.....	....	......	136.5	133.20	14 May.
......	....	....	138.2	.....	....	......	145.9	142.05	23 "
......	....	.... .	131.6	......	....	.....	140.6	136 10	17 "
......	....	......	132.0	......	....	.....	140.4	136.20	17 "
......	....	......	154.0	......	....	......	159.1	156.55	6 June.
......	....	......	159.2	......	....	......	166.4	162.80	12 "
......	....	......	146.9	......	....	......	152.4	149.65	30 May.
.. ...	....	......	160.3	......	....	......	166.9	163.60	13 June.
.... .	....	......	167.8	......	... .	......	172.2	170.00	20 "
......	....	......	143.06	......	....	.....	150.19	146.62	27 May.

Flowering Phenochrons — *Continued.*

CAPE BRETON COUNTY, 1899.

First Seen.				Becoming Common.				General Phenochrons.	
Coast.	Low Inlands.	High-lands.	Aver-age.	Coast.	Low Inlands.	High-lands.	Aver-age	Annual date.	Mensual date.
......	....	......	111.8	......	....	......	120.8	116.30	27 April.
......	....	......	132.0	......	....	......	137.9	134.95	15 May.
......	....	......	128.0	......	....	......	134.5	131.25	12 "
......	....	......	132.2	......	....	......	139.4	135.80	16 "
......	....	......	127.7	......	....	......	138.7	133.20	14 "
......	....	......	150.6	......	....	......	156.3	153.45	3 June.
......	....	......	149.2	......	....	......	160.7	154.95	4 "
......	....	......	147.2	......	....	......	152.9	150.05	31 May.
......	....	......	156.6	......	....	......	163.4	160.00	10 June.
......	....	......	164.9	......	....	......	170.3	167.60	17 "
......	....	......	140.2	......	....	......	147.49	143.75	24 May.

INVERNESS COUNTY, 1899.

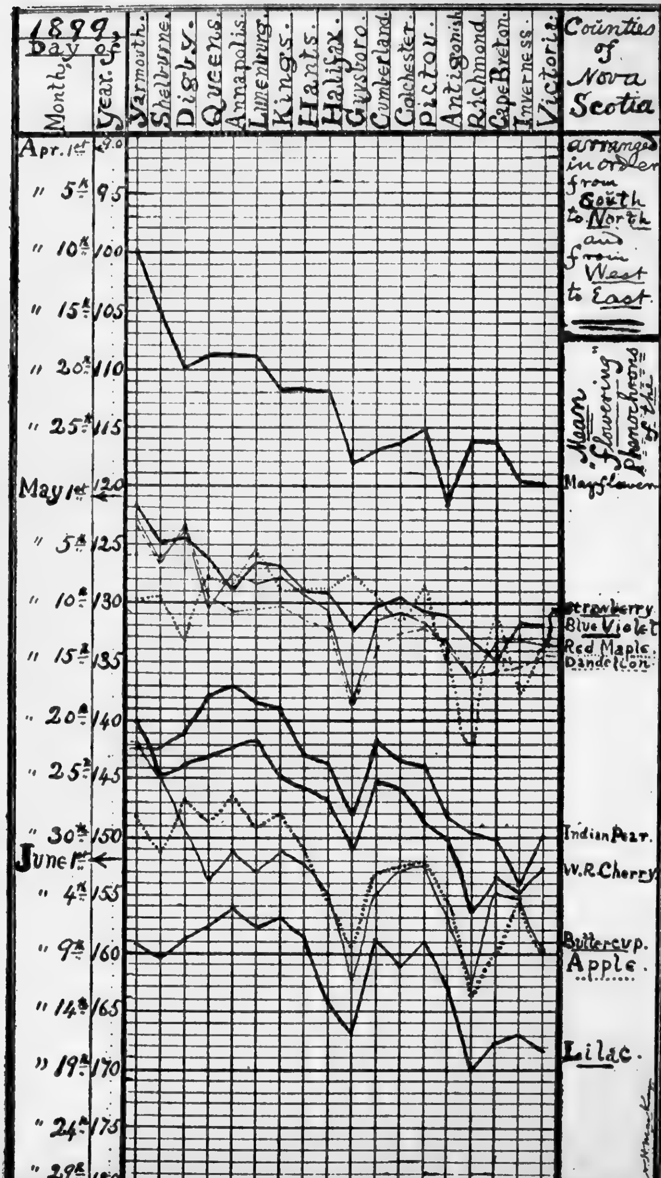
.....	....	......	116.5	......	....	....	122.8	119.65	30 April.
......	....	......	128.1	......	....	......	135.3	131.70	12 May.
.....	....	......	134.1	......	....	......	141.2	137.65	18 "
.....	....	....	131.9	......	....	....	138.9	135.40	16 "
......	....	.....	129.7	.....	....	.....	136.6	133.15	14 "
......	....	.....	151.9	......	....	......	157.7	154.80	4 June.
.....	....	.....	151.2	......	....	......	159.3	155.25	5 "
......	....	......	148.7	......	....	......	159.6	154.15	4 "
......	....	.....	152.9	......	....	......	158.5	155.70	5 "
......	....	.....	163.8	.....	....	......	170.1	166.95	16 "
......	....	... ..	140.88	.....	....	... ..	148.00	144.44	25 May.

VICTORIA COUNTY, 1899.

......	....	.....	117.2	... .	.....	......	122.3	119.75	30 April.
.... .	....	......	129.9	......	....	.....	133.6	131.75	12 May.
...	....	......	130.3	......	....	... .	136.8	133.55	14 "
......	....	... .	131.7	......	....	....	137.3	134.50	15 "
......	....	......	127.9	......	....	......	135.5	131.70	12 "
......	....	......	149.8	...	....	....	155.2	152.50	2 June.
.... .	....	.....	155.8	....	....	......	163.5	159.65	9 "
...	....	... .	147.2	......	....	... ..	152.7	149.95	30 May.
. ....	....	....	157.1	......	....	.....	162.8	159.95	9 June.
......	....	... .	164.7	....	....	....	171.8	168.25	18 "
......	....	....	141.16	... ..	....	. ..	147.15	144.15	25 May.

Phenochron Curves of Flowering.

(Mean of "*first* seen" and "*becoming* common").



Observations of Botanical Club of Canada.

In order to keep unbroken the series of observations made by the Botanical Club of Canada, in the Transactions of the Institute, especially as they have not yet become too voluminous, the following tabular summation of them for 1899 is given. The *seven* stations in the other provinces of the Dominion show observations which will be interesting in comparison with those made in Nova Scotia.

Phenological Stations and Observers of the Botanical Club of Canada, 1899.

St. Stephen, N. B.—J. Vroom, Esq.
Yarmouth, N. S.—S. A. Starratt, Esq.; Seymour Critcher, Esq.
Berwick, N. S.—Miss Ida A. Parker.
Halifax, N. S.—Harry Piers, Esq.
Musquodoboit Harbour, N. S.—Rev. James Rosborough.
New Glasgow, N. S.—Miss Maria Cavanagh.
Wallace, N. S.—Miss Mary E. Charman.
Charlottetown, P. E. I.—John McSwain, Esq.
Beatrice, Muskoka, Ontario.—Miss Alice Hollingworth.
Pheasant Forks, Assiniboia.—Thomas R. Donnelly, Esq.
Olds, Alberta.—T. N. Willing, Esq.
Willoughby, Saskatchewan.—Rev. C. W. Bryden.
Vancouver, B. C.—J. K. Henry, Esq., B. A.

Explanation of Annotations over the Date Figures in the following Table:

*—" When becoming common."
b—Rubus spectabilis (flowering).
c— " " (fruiting).
f—Rubus occidentalis.
k—Turdus propinqua.
o—Sturnella neglecta.
q—Chordeiles Henryei.
s — Ranunculus rhomboideus.
t — Fragaria Chilensis.
u — Prunus emarginata.
v — Trillium ovatum.
w—Trientalis Europœa.
x — Amelanchier alnifolia.
y — Rosa Nutkana.

PHENOLOGICAL OBSERVATIONS, CANADA, 1899.

Number.	Day of the year 1899 corresponding to the last day of each month. Jan. .... 31 July ....212 Feb. .... 59 Aug ....243 March .. 90 Sept ....273 April ...120 Oct .....304 May ....151 Nov.....334 June ...181 Dec. ....365 (First flowering or fruiting of plants and first appearance of migratory animals, etc.)	St. Stephen, N. B.	Yarmouth, N. S.	Berwick, N. S.	Halifax, N. S.	Musquodoboit, N. S.	New Glasgow, N. S.	Wallace, N. S.	Charlottetown, P. E. I.	Beatrice, Muskoka, Ont.	Pheasant Forks, Assa.	Olds, Alberta.	Willoughby, Sask.	Vancouver, B. C.
1	Alnus incana, Willd....	103	112	....	112	....	*111	....	*121	*113	....	....	....	68
2	Populus tremuloides, Michx.	106	....	...	120	....	121	....	*138	*116	144	126	....	....
3	Epigæa repens, L.........	112	99	96	106	105	112	....	*115	...	....	....	....	....
4	Viola cucullata, Gray	123	119	126	....	....	*129	....	*124	*119	144	....	....	....
5	V. blanda, Willd........	....	119	122	131	119	122	....	*124	*119	148	....	....	....
6	Acer rubrum, L...........	118	....	....	....	133	122	....	...	*119	....	....	....	...
7	Houstonia cærulea, L	....	....	....	....	130	122	....	....	....	....	....	....	....
8	Equisetum arvense, L....	....	115	134	....	....	120	....	....	*132	....	....	....	92
9	Taraxacum officinale, Weber.	121	115	112	123	125	119	....	....	*124	....	....	...	....
10	Erythronium Amer., Ker.	....	...	....	....	....	126	....	....	*119	....	....	....	....
11	Hepatica triloba, Chaix..	....	145	....	....	132	...	....	....	....	....	....	....	....
12	Coptis trifolia, Salisb....	....	....	133	123	....	144	....	*157	*132	....	....	....	....
13	Fragaria Virginia, Mill ..	127	117	122	*132	126	122	....	*146	128	152	127	....	[t] 114
14	" (fruit ripe)	167	152	158	*175	....	160	....	....	*176	186	....	....	....
15	Prunus Pennsyl., L.......	....	....	142	149	154	146	....	....	132	....	....	.. .	[u] 122
16	(fruit ripe)	....	....	....	....	....	....	....	....	....	221	....	. .	....
17	Vaccinium Penn., Lam...	....	137	133	....	127	157	....	....	....	....	...	....	....
18	" (fruit ripe)	159	...	....	190	....	....	....	....	....	....	....	....	....
19	Ranunculus acris, L......	150	[illegible]	147	....	163	128	....	....	*163	...	[s] 128	....	. .
20	R. repens, L...............	151	....	....	154	....	....	...	...	....	....	....	....	132
21	Clintonia borealis, Raf....	....	155	141	....	157	*157	....	....	....	....	....	....	....
22	Trillium erythrocarpum, Michx.	131	....	142	....	157	144	....	....	*139	....	....	....	[v] 88
23	Trientalis Ameri., Pursh.	150	119	127	154	158	151	....	154	*139	....	....	...	[w] 131
24	Cypripedium acaule, Ait.	...	...	152	....	160	147	....	....	....	...	....	....	....
25	Calla palustris, L.........	....	...	....	....	158	.. .	....	....	152	....	....	....	....
26	Amelanchier Canadensis T. & G.	129	...	134	143	134	141	....	...	128	...	....	....	[x] 126
27	" (fruit ripe)	...	....	....	204	...	....	....	...	....	....	....	...	....

PHENOLOGICAL OBSERVATIONS, CANADA, 1899.

Number.	Day of the year 1899, corresponding to the last day of each month. Jan. .... 31 July.....212 Feb.... 59 Aug ....243 March .. 90 Sept ... 273 April....120 Oct......304 May.....151 Nov.....334 June....181 Dec.....365 (First flowering or fruiting of plants and first appearance of migratory animals, etc.)	St. Stephen, N. B.	Yarmouth, N. S.	Berwick, N. S.	Halifax, N. S.	Musquodoboit, N. S.	New Glasgow, N. S.	Wallace, N. S.	Charlottetown, P. E. I.	Beatrice, Muskoka, Ont.	Pheasant Forks, Assa.	Olds, Alberta.	Willoughby, Sask.	Vancouver, B. C.
28	Rubus strigosus, Michx	....	....	....	....	....	171	....	....	152	181	....	....	b 78
29	" (fruit ripe)	....	....	....	....	....	...	....	...	191	199	....	....	c 159
30	Rubus villosus, Ait.	....	....	....	175	...	..	....	....	163	....	....	....	f 149
31	" (fruit ripe)	....	....	....	232	....	....	....	....	228	....	....	....	....
32	Kalmia glauca, Ait	150	....	....	....	156	...	...	....	....	....	....	....	140
33	K. angustifolia, L.	....	....	151	213	179	171	....	....	....	....	....	....	....
34	Cornus Canadensis, L.	....	....	134	149	....	161	....	*164	*162	...	....	....	133
35	" (fruit ripe)	....	....	....	....	....	....	....	....	....	....	....	....	...
36	Sisyrinchium angustifol.	....	152	152	....	156	163	...	....	....	....	....	....	....
37	Linnæa borealis, L.	....	168	....	...	170	....	....	....	155	....	....	....	....
38	Linaria Canaden., Dum.	....	....	....	*221	....	....	....	...	....	....	....	....	....
39	Rhinanthus Crista-galli, L.	....	....	....	182	....	....	....	....	....	....	....	....	....
40	Sarracenia purpurea, L.	....	..	178	....	182	....	....	...	....	....	....	....	....
41	Brunella vulgaris, L.	....	....	172	....	182	...	....	....	...	....	....	....	....
42	Epilobium augustifol., L.	...	....	....	195	201	*198	198	....	*194	....	....	....	....
43	Rosa lucida, Ehrh	....	142	168	183	...	....	...	....	...	....	....	....	y 144
44	Hypericum perforat., L.	....	....	213	189	....	192	...	....	155	....	....	....	....
45	Leontodon autumnale, L.	....	151	171	183	174	167	....	....	?	....	....	....	....
46	Prunus Cerasus (cultiv.)	135	....	....	150	....	146	...	*154	....	..	....	....	112
47	" (fruit ripe)	162	....	....	....	....	....	196	...	....	....	....	....	174
48	Cratægus Oxyacantha, L.	....	....	....	....	...	165	....	*163	....	....	....	....	152
49	C. coccinea, L.	....	....	....	....	....	152	....	.	....	....	....	....	....
50	Prunus domestica (cul'd).	....	158	146	153	....	146	....	....	128	...	....	....	....
51	Pyrus malus (cul d) early.	133	157	....	....	...	150	....	....	144	....	...	....	123
52	" " late	....	..	....	....	....	156	...	*157	...	....	....	....	....
53	Ribes rubrum (cultivated)	....	....	....	....	..	148	....	....	128	154	....	....	....
54	" (fruit ripe)	161	....	....	....	....	...	...	....	....	...	...	....	....

PHENOLOGICAL OBSERVATIONS, CANADA, 1899.

Number.	Day of the year 1899, corresponding to the last day of each month. Jan. ..... 31 July.....212 Feb. ..... 59 Aug. .....243 March.. 90 Sept ...273 April ...120 Oct. .....304 May ....151 Nov .....334 June ...181 Dec .....365 (First flowering or fruiting of plants and first appearance of migratory animals, etc.)	St. Stephen, N. B.	Yarmouth, N. S.	Berwick, N. S.	Halifax, N. S.	Musquodoboit, N. S.	New Glasgow, N. S.	Wallace, N. S.	Charlottetown, P. E. I.	Beatrice, Muskoka, Ont	Pheasant Forks, Assa.	Olds, Alberta.	Willoughby, Sask.	Vancouver, B. C.
55	R. nigrum (cultivated)....									132				
56	" (fruit ripe)													
57	Syringa vul., L. (cultiv.)..	143	160	153	160		153		*161	144	168			128
58	Solanum tuberosum, L. ..			171						*182	210			
59	Phleum pratense, L				150					*185				
60	Trifolium repens, L.......		139				156			132				
61	T. pratense, L.......		151	156	157	174	155			*166				
62	Triticum vulgare, L......										212			
63	Avena sativa, L..........													
64	Fagopyrum esculen., L...													
65a	Earliest full leaf'g of tree.			151						128				
65b	Latest " "													
66	Ploughing (first of season)		96							121			115	
67	Sowing " "								*126	126	128		117	
68	Potato-planting "							121		130	144		128	
69	Sheep-shearing "									136	153		156	
70	Hay cutting "				190					193	210		198	
71	Grain-cutting "								*236	233			241	
72	Potato-digging "						258			268	258		276	
73a	Opening of rivers "						100		110		111		107	
73b	Opening of lakes . "				112									
74a	Last snow to whiten gr'd.	90		116			124	124				133	123	
74b	" to fly in air....				124						135	156		
75a	Last spring frost—hard...									135				
75b	" " hoar...			149					143					155
76a	Water in streams—high..										111		115	
76b	" " low ..													

PHENOLOGICAL OBSERVATIONS, CANADA, 1899.

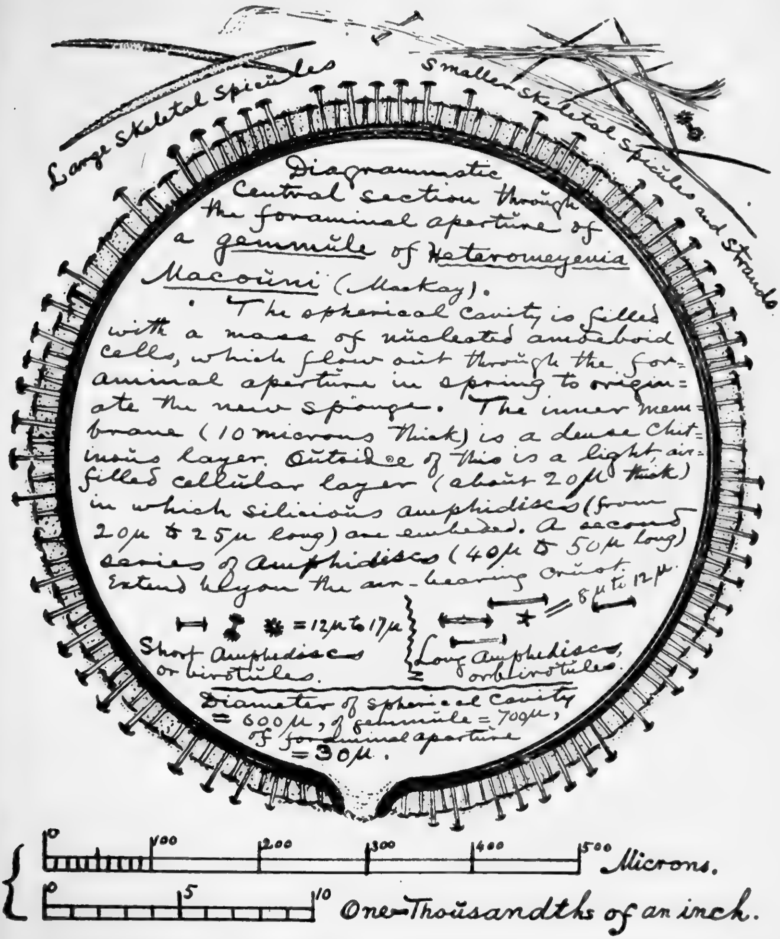
Number.	Day of the year 1899, corresponding to the last day of each month. Jan. .... 31 July.....212 Feb. .... 59 Aug.....242 March .. 90 Sept.....273 April... 120 Oct .....304 May ....131 Nov.. ..334 June....181 Dec .....365 (First flowering or fruiting of plants and first appearance of migratory animals, etc.)	St. Stephen, N. B.	Yarmouth, N. S.	Berwick, N. S.	Halifax, N. S.	Musquodoboit, N. S.	New Glasgow, N. S.	Wallace, N. S.	Charlottetown, P. E. I.	Beatrice, Muskoka, Ont.	Pheasant Forks, Man.	Olds, Alberta.	Willoughby, Sask.	Vancouver, B. C.
77a	First autumn frost, hoar.	227	....	....	258	....	258	....	251	....	254	221	221	....
77b	" " hard..	....	....	....	307	....	....	....	....	....	....	....	....	....
78a	First snow to fly in air....	276	....	....	..	....	...	277	315	....	....	....	....	....
78b	" whiten ground	294	....	....	316	....	307	294	317	....	....	....	....	....
79a	Closing of Lakes..........	....	....	....	....	....	....	319	370	....	....	...	....	....
79b	" Rivers.........	....	....	....	...	....	341	....	....	....	....	....	....	....
80	Thunderstorms—dates....	64	64	64	....	....	64	5	64	....	....	....	....	....
		.. .	78	....	....	....	....	64	....	104	....	108	....	....
		122	122	....	....	...	....	121	....	120	126	....	....	....
		146	....	....	...	....	....	128	....	148	....	142	....	....
		156	156	....	....	....	....	164	....	149	....	....	....	....
		157	....	157	157	....	....	....	165	151	....	162	....	...
		165	....	....	....	...	....	....	....	155	.. .	169	....	....
		170	166	....	....	....	166	167	....	156	....	....	....	. ..
		171	....	....	....	...	....	....	....	157	172	188	....	....
		172	....	172	....	....	....	172	....	163	173	 200	....	....
		176	176	....	....	....	....	174	....	165	175	....	....	....
		177	....	....	....	....	177	176	176	174	177	219	....	....
		185	..	...	....	....	....	181	177	184	178	....	....	....
		187	....	....	....	...	....	....	186	198	197	220	....	....
		194	....	....	....	....	194	194	194	214	204	221	....	....
		202	....	....	....	....	195	202	195	224	210	...	....	....
		208	....	....	....	....	....	....	200	233	212	236	....	....
		210	....	....	....	....	....	225	201	...	218	255	....	....
		....	....	216	....	....	....	....	202	....	221	....	....	....
		246	....	....	....	...	246	246	220	...	229	259	....	....
		....	....	....	316	....	247	273	226	260	231	....	....	....

PHENOLOGICAL OBSERVATIONS, CANADA, 1899

Number.	Day of the year 1899, corresponding to the last day of the month. Jan. .... 31 July.....212 Feb..... 59 Aug. .....243 March .. 90 Sept ....273 April .. 120 Oct... ..304 May.....151 Nov ....334 June... 181 Dec.....365 (First flowering or fruiting of plants and first appearance of migratory animals, etc.)	St. Stephen, N. B.	Yarmouth, N. S.	Berwick, N. S.	Halifax, N. S	Musquodoboit, N. S.	New Glasgow, N. S.	Wallace, N. S.	Charlottetown, P. E. I.	Beatrice, Muskoka, Ont.	Pheasant Forks, Man.	Olds, Alberta.	Willoughby, Sask.	Vancouver, B. C.
80	Thunderstorms—dates....	....	....	....	....	....	....	....	228	287	....	....	....	....
		....	....	....	....	....	....	....	246	296	....	....	....	....
		....	....	....	....	....	....	....	257	....	....	....	....	....
		....	....	....	....	....	....	....	....	....	....	....	....	....
		....	....	....	....	....	....	....	....	....	....	....	....	....
81a	Wild ducks migrating, N.	....	....	86	..	....	....	....	....	....	110	99	....	....
81b	" " S.	....	....	....	....	....	....	....	....	....	....	....	....	....
82a	" geese " N.	100	94	78	81	....	....	....	90	....	110	100	....	....
82b	" " S.	....	347	....	....	....	....	....	246	291	....	286	....	....
83	Melospiza fasciata, North.	105	92	94	94	....	....	....	98	....	....	....	....	....
84	Turdus migratorius, "	102	80	88	97	....	100	....	96	....	*k* 116	*k* 97	*k* 116	....
85	Junco hiemalis, "	....	102	81	99	....	....	....	112	....	....	....	....	....
86	Actitis macularia, "	....	....	....	....	....	....	....	....	....	....	....	....	....
87	Sturnella magna "	....	....	....	....	....	....	....	....	....	*o* 106	....	....	....
88	Ceryle Alcyon. "	....	102	....	....	....	....	....	....	....	....	....	....	....
89	Dendrœca coronata, "	....	149	....	144	....	....	....	....	....	....	....	....	....
90	D. æstiva, "	....	....	....	?	....	146	....	....	....	....	....	....	....
91	Zonotrichia alba, "	120	....	....	....	....	....	....	134	....	....	....	....	....
92	Trochilus colubris, "	143	128	135	....	....	144	....	....	....	....	....	....	....
93	Tyrannus Carolinen , "	....	....	145	....	....	....	....	....	....	....	....	....	....
94	Dolychonyx oryzivor.,"	....	....	....	....	....	....	....	....	....	....	....	....	....
95	Spinis tristis, "	144	....	....	..	....	....	....	....	....	....	....	....	....
96	Setophaga ruticilla, "	....	....	....	146	....	....	....	....	....	....	....	....	....
97	Ampelis cedrorum, "	....	....	....	....	....	....	....	....	....	....	....	....	....
88	Chordeiles Viginian., "	....	151	....	149	....	....	....	156	....	*q* 148	....	....	....
99	First piping of frogs......	115	106	97	112	....	144	....	117	107	115	108	110	....
100	First appearance, snakes.	....	109	....	....	....	....	....	....	123	127	....	....	....

XIV.—A Fresh Water Sponge from Sable Island.—By A. H. MacKay, LL. D., *Halifax.*

(Read 9th April, 1900.)



This sponge was collected in considerable abundance on the 18th of August, 1899, by Professor John Macoun, Botanist of

the Geological Survey of Canada, in the fresh water pond found in the centre of that great sand-shoal in the Atlantic Ocean, well known as Sable Island, nearly one hundred miles from Nova Scotia, the nearest part of the continent. It was growing around the submerged portion of the slender stems of *Myriophyllum tenellum*, Bigelow, in green, compact, lobular masses, showing, where broken, numerous orange yellow gemmules.

It appears to approach most nearly to the following fresh water sponges described by Potts: *Heteromeyenia ryderi, v. baleni*, found from Florida to New Jersey, in its spiculation; and *Heteromeyenia ryderi v. walshii*, from Gilder Pond, Massachusetts, in the fasciculation of its skeleton spicules.

General form: Encrusting the submerged stems of *Myriophyllum tenellum*, (which in the specimens examined are about 2 mm. thick), in a smooth, compact, green, lobular mass extending to a gross diameter of about one centimeter, and to a height or length along the stem of about 5 or 6 centimeters in some cases, the lobes suggesting an abortive attempt at branching; pores and osteoles very minute; gemmules very abundant, appearing wherever the central mass is broken.

Gemmules: Light orange in color, spherical, varying from 500 to 800 microns in diameter, but generally between 600 to 700 microns; foraminal aperture from 30 to 70 microns in diameter, not produced into a tube beyond the crust; dense inner (chitinous) coat of gemmule nearly 10 microns thick, surrounded by the light cellular crust (in which the short siliceous birotules or amphidisks are vertically embedded) to a depth of about 25 microns; both short and long birotules or amphidisks with one disk or rotule resting on the chitinous coat, their shafts radially directed, packed as closely as their disks allow, the long birotules being fewer with the distal rotules extending beyond the crust, their few slightly incurved rays somewhat adapted for attaching the gemmule to any finely fibrous environment.

Short birotules: From 18 to 26 microns in length, generally from 20 to 24, with a smooth uniform shaft

ranging from 1.5 to 2 microns thick; the rotules being plane disks less than 2 microns thick from the point where the shaft begins to swell into them, and from 10 to 16 microns in diameter, commonly near 12 microns, laciniately blunt-lobed around their margins, the shaft occasionally extending 1 micron beyond the disks, making the exterior of the rotule slightly umbonate.

Long birotules: From 35 to 50 microns, commonly from 40 to 45, with usually a smooth, uniform shaft about 2 microns thick; the rotules generally of 3, to 4 or 5 rays which are slightly incurved, the rotule ranging from 8 to 14 microns in diameter, commonly from 10 to 11 microns.

Larger skeleton spicules: Slightly curved, microspined or rough, tapering gradually from the middle, then more rapidly towards the ends; ranging from 150 to 260 microns in length, commonly from 180 to 220; and from 3.5 to 5 microns in breadth at the thickest part.

Intermediate skeleton spicules: Generally smooth, and from 2 to 3 microns thick, and from 150 to 200 microns in length, numerous and generally fascicled into strands which are often connected transversely by the larger spicules.

Smaller strand spicules and filament strands: Finer strands than those referred to above, appearing as if made up of continuous filaments instead of spicules; strands commonly from 10 to 15 microns across, made up of about 20 filaments or more, each about one micron thick, where broken across appearing as if they were flexible to some extent, the ends of the filaments showing a more or less distinct curvature. Under the microscope they appear identical with the more slender spicules with the exception that they appear to be continuous in the strand. Examined with polarized light they are visible in the dark field, as are also, more or less, the strands made up of the intermediate spicules while the spicules are cemented together, suggesting a peculiar colloidal siliceous or a spongin cement. When heated with nitric acid these filaments appear first to separate and break into pieces, then partly at least to disappear. At the earliest opportunity I purpose to examine the nature of these

strands and their relationship to the other portions of the skeleton; but this crude provisional treatment of them suggested that the filaments might be spongin fibres partly silicified, or nascent siliceous spicules.

The two classes of birotules arming the gemmule put the sponge into Potts's genus *Heteromeyenia*. I therefore propose the name *Heteromeyenia macouni*, in allusion to the distinguished naturalist who discovered it. It is possible that a comparison of the sponge with the two varieties referred to first above as approximating to this species may reduce it to *Heteromeyenia ryderi v. macouni*; but from the descriptions published it appears to be specifically distinct.

The sponge is especially interesting on account of its habitat in the only fresh water pond of a sand island in the Atlantic Ocean nearly 100 miles from the continent. The island is about 20 miles long at present and about one mile broad. It has been described as consisting of "two parallel ridges of loose grey sand, in a bow or crescent shape, with the inner side to the north. In the valley between these is a lake, now not more than eight miles long, formerly nearly twice that length."* This is the pond in which *Heteromeyenia macouni* has been growing in abundance.

---

* Sable Island: Its History and Phenomena, by Rev. George Patterson, D. D., in Transactions of the Royal Society of Canada, Section II., 1894, (3).

Date of Publication; December 31st, 1900.

TRANSACTIONS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1900-1901.

I.—Geological Nomenclature in Nova Scotia.—By Hugh Fletcher, B. A., *of the Geological Survey of Canada.*

(Communicated 10th December, 1900.)

New Glasgow Conglomerate.

Another of the debatable questions in Nova Scotian geological classification is that of the age of the New Glasgow Conglomerate.

This formation is thus described by Sir William Logan:

"At the bridge of New Glasgow is exposed a series of conglomerates, which, in general colour, are between a brick-red and chocolate or Indian-red, and whose inclosed masses, varying from the smallest pebbles to boulders of two feet in diameter, are, for the most part, unmistakably derived from the red and greenish-gray sandstones, red shales and impure nodular limestones of the Millstone Grit, some of them containing the same vegetable organic remains. With these pebbles and boulders are associated a few from the rocks still lower down. The whole are inclosed in a matrix of the same mineral character, constituting an argillo-arenaceous cement, which is also calcareous, and in the interstices of the boulders and pebbles is often observed a network of white calcspar aiding to keep them together. There are interstratified in the rock, bands, from a few inches to several feet in thickness, of fine red sandstone and red shale, which serve to give assurance of the dip, and these occur at such distances apart as to render the conglomerate beds thick and

massive, their transverse measure varying from ten to sometimes nearly 100 feet.

"From a point a short distance above the bridge, to one much farther below, these conglomerates have a breadth of very nearly a mile, giving a total thickness of about 1,600 feet. This great mass of conglomerate composes Fraser's Mountain, towards the south flank of which, presenting the outcrop escarpment of the inferior part, the red and gray strata of the Millstone Grit dip in such a way as, without other evidence, to induce the supposition that the one series overlies the other comformably. But on the west side of the East River Mr. Hartley has evidence to show that there is a want of conformity, at least in some places.

"Three miles eastward of New Glasgow these conglomerates have a breadth of about fifty-four chains, and they are here immediately and conformably overlaid by the following ascending section:

	ft.	in.
Gray limestone which has been quarried for burning	20	0
Measures concealed	10	0
Bluish-gray slightly calcareous sandstone		5
Bluish-brown concretionary limestone, the surface of which presents concentric botryoidal thinly laminated concretions, with grayish and red clay in the interstices and inequalities		10
Gray and red clay		8
Reddish concretionary limestone, with concentric botryoidal laminae as before	1	0
Whitish-gray limestone	1	0
Gray and red mottled clay, resembling fireclay	1	4
Glay flaggy sandstone	1	8
Gray clay		6
Whitish arenaceous limestone, holding abundance of *Spirorbis arietina*	2	2
Grayish-blue, spotted, slightly argillaceous sandstone	1	0
Measures concealed, including several feet of underclay ..	24	0
Coal and black carbonaceous shale, including about eighteen inches of good coal at the bottom, which used to be mined by Mr. W. Fraser, for the purpose of burning the limestone in the lower part of the section	4	5
	69	0

"Very nearly on the strike they are again met with on a brook on the property of Mr. James Small, on the road to Little Harbour, Merigomish. The one locality is as much as three miles from the other; but the botryoidal concretionary limestone layers in both are so peculiar and so strikingly like in appearance, and in their relation to any overlying seam of coal, that no doubt can be entertained of their equivalence; and I have no evidence yet to shew that the mass is here of less volume than farther to the west."

Another exposure of these rocks, 1,372 feet in thickness, occurs at Alma mills bridge on the Middle River, beyond which they reappear in Rogers Hill and Mount Dalhousie at the eastern end of the Cobequid range, also at the head of River John, and in considerable thickness on Waugh River. To the eastward, they have been followed through Quarry and Olding Islands to the Big Island of Merigomish.

In tracing them west from New Glasgow to the Middle River, they appear along the northern flank of Waters Hill to directly overlie the altered Devonian rocks of that locality. Exposures would seem to give direct proof of the unconformity of the conglomerate with the rocks of the Millstone Grit, which unconformity we should naturally have expected from the presence of pebbles derived from rocks of the latter division in the former.[1]

Of these rocks Gesner wrote thus in 1836:[2] "The red sandstone * * * covering the great coal basin of Pictou * * * is often associated with beds of conglomerate * * * these towards the surface seem to pass insensibly into a red soft sandstone, which from its ready disintegration yields a rich and fertile soil." At the same time, however, he correlates the Mountain Limestone with the Permian of Caribou Harbour and Pictou Island; while certain fossils of that limestone at Economy and Merigomish he calls *Belemnites* and *Ammonites*.

---

[1] Logan and Hartley—Geol. Survey Report 1866-69, pages 13 to 15 and 64 to 66.
[2] Geology and Mineralogy of Nova Scotia, pages 141, 134, 126 and 29.

In 1845, Sir J. W. Dawson described these rocks as follows: "The coal measures of the Albion Mines, on the banks of the East River of Pictou * * * are succeeded, in ascending order, by a great bed of coarse conglomerate, which, as it marks a violent interruption of the processes which had accumulated the great beds of coal, shale and ironstone beneath, and as it is succeeded by rocks of a character very different from that of these older coal measures, forms a well-marked boundary, which we may consider as the commencement of the Newer Coal Formation.[1]"

The fossils of this latter, he adds, show the continuance of the coal flora with terrestrial vertebrate animals through a thickness of 5,000 feet or more.

This description indicates what seems to be the true structure; yet in 1853[2] he prefers to regard the conglomerate as a gravel beach contemporaneous with the Albion coal measures, which it "guarded against the disturbing causes which in other localities prevented the continuous accumulation of coal."

In 1868[3] he argues in favor of the theory that "the New Glasgow conglomerate is to be regarded as an anomalous and peculiar modification of the Millstone Grit, succeeded in ascending order on the south side by the great coal measuress of the Albion Mines, and on the north by a depauperated representative of these beds, graduating upward into the Upper or Newer Coal measures;" and in 1878[4] again assigns it to "the upper part of the Millstone Grit or lower part of the Middle Coal formation," the depauperated Albion mines measures being the 660 feet next overlying, succeeded conformably by the "Upper Coal formation."

The physical conditions under which a beach of shingle could accumulate 1,600 feet of coarse conglomerate contemporary and in juxtaposition with 5,567 feet of beds of entirely different character, including more than 2,000 feet of black bituminous

[1] Quarterly Journal of the Geological Society of London, Vol. I., p. 322. Cf. also Trans. N. S. Inst. Nat. Sc., Vol. II., p. 95, Vol. II., Part 3, page 155.

[2] Geol. Jour. X, pp. 42-47; Acadian Geology, First Edition, 1855, p. 249.

[3] Acadian Geology, Second Edition, pp. 322-326.

[4] Suppl. Acad. Geol., pp. 34 and 49.

shales and many large seams of coal, seemed so anomalous, that Sir William Logan naturally set aside as untenable the supposition of contemporaneity with the Albion coal measures, tacitly classified the conglomerate beneath the latter, but coloured it on his map of the Pictou coal field as distinct from both the Coal Measures and the Millstone Grit. "No rocks," he says,[1] "having the typical character of this conglomerate appear to have been brought to the surface by either the south or the east fault, or by Mr. Hartley's west fault. This does not, however, disprove their possible presence beneath the whole of the productive area abutting against these faults and constituting the base of Dr. Dawson's Middle Coal formation, as inferred by Mr. Hartley."

"This inference seems to be supported by the presence, immediately on the summit of the conglomerate, of the coal seam worked by Mr. William Fraser (Moose) for the burning of his limestone, and another said to overlie it; and although the occurrence of these is not strengthened by the known existence of any of the larger workable coal seams in the Pictou synclinal, the deposits of which have yet to be examined by the officers of the Survey, it would not be surprising to find, in a country apparently so broken by great dislocations, that the absence of the larger seams may be due to a structure resulting from some of these faults, of as important a character as those affecting the productive part of the field above New Glasgow."

Since 1869, however, the district referred to has been closely examined by the Geological Survey, shown to be broken by no great dislocations, but on the contrary to be occupied by undisturbed strata which conformably overlie the conglomerate and are equivalent to those above the productive coal measures of the Joggins section. A glance at the geological map of this district will suffice to show that the conglomerate is the natural base of the Upper Carboniferous or Permian rocks of Merigomish, Pictou, River John and Waugh River.

In support of Sir J. W. Dawson's later views it has been stated that the fossils of the strata immediately overlying the

[1] Geol. Surv. Rep. for 1866-69, page 52.

conglomerate at the East River more nearly resemble those of the coal measures of McLellan Brook than those from Permian rocks.[1] But when we remember the vagaries of this method of classification with regard to fossils from the Millstone Grit in Cape Breton[2] and in New Brunswick,[3] and the striking similarity of fossils from these formations both in Europe and America,[4] too much importance need not be attached to such a statement.

Mr. R. G. Haliburton in 1867[5] inferred, on evidence obtained from explorations undertaken for the practical purpose of discovering and developing coal mines, that discoveries similar to those already made must soon be made in other directions. He described the Pictou coal basin as constituting two distinct basins, the one lying to the southward and the other to the northward of the conglomerate, which, according to him, underlies the productive measures. But he could find no equivalents of the southern coal measures in the northern basin and assumes that they were always distinct basins, and now differ from their measures having been formed under different circumstances.

On the assumption that the conglomerate was the base of a coal formation, the productive portion of which was concealed by unconformity and might be reached, a borehole was in 1876 put down 734 feet, under the direction of Sir Wm. Dawson, at Sutherland Point on the East River below New Glasgow. No such coal measures were, however, found to intervene.

In 1893, Mr. H. S. Poole, whose intimate knowledge of the field is the result of many years of close observation and study,[6] discussed the geological position of the New Glasgow Conglomerate in a paper on the Pictou coal field, classifying it as the base of his Permian series while pointing out that it has an interest of a practical character in connection with the

---

[1] Trans. N. S. Inst. Sc. Vol. X, Session 1899-1900, p. 178; Sum. Rep. Geol. Surv. 1897, p. 134.

[2] Geol. Survey Report for 1874-75, page 192.

[3] Geol. Sur. Can. Report for 1872-73, page 222 and subsequent reports and maps.

[4] Geol. Mag., London, May 9, 1900; Acadian Geology, p. 283; Trans. N. S. Inst. Sc. Vol X, p. 235.

[5] Trans. N. S. Inst. Sc., Vol. II, Part 1, p. 93 and Vol. II, Part 3, p. 155.

[6] Trans. N. S. Inst. Sc., Ser. 2, Vol. I, Part 3, p. 240.

possible extension of the coal seams beneath it. He showed clearly that there is no recognized unconformity between the Millstone Grit and Coal Measures in Nova Scotia, that no beds equivalent to the conglomerate are known in the southwest part of the Pictou field, where the Millstone Grit is best exposed in regular sequence under the coal measures, and that the supposition that "the underlying strata of the Richardson seam rested upon the conglomerate dipping to the southward,"[1] which largely led Dawson to put the New Glasgow Conglomerate at the base of the coal measures, arose from an entire misconception of the relation of this seam, (which lies high up in the coal measures, 1129 feet above the main seam), to the north fault.

Mr. Poole showed further that although the conglomerate apparently coincides in dip with the strata underlying it in the district of Pine Tree, its unconformity near the East River west of New Glasgow is indisputable. In the country about Greenhill, the Middle River and Plainfield, it rests only on metamorphic and Lower Carboniferous rocks. The Devonian rocks of Waters Hill "are certainly not overlaid by deposits of an age intermediate between Lower Carboniferous and the conglomerate," while the latter contains pebbles of strata evidently newer than the Lower Carboniferous, regarded by Logan as Millstone Grit, by Poole, as possibly upper coal measures.

The coal measures are nowhere known to rest on the conglomerate and "the strata overlying it are, with the exception of the till, the highest in the field," comparatively little disturbed, everywhere comformable to it and in some parts of their course holding fossils supposed to be characteristic of the upper Carboniferous or Permian and Triassic. On the other hand, the unconformity found below it is characteristic of the contact of the base of these so-called Permo-Carboniferous rocks, as shown on Dr. Ells' geological map of Cumberland County.[2]

[1] Trans. N. S. Inst. Sc., Vol. II, Part 1, p. 96 and Vol. II, Part 2, p. 156.

[2] G. S. C. Report for 1885, Part E.

NOTE.—Reference to the map accompanying Mr. Poole's paper on the Pictou Coal Field, Trans. N. S. Inst. Sc., vol. viii, (2nd ser., vol. i), p 223, will facilitate the understanding of these notes on the New Glasgow Conglomerate. On Mr. Poole's map the limits of that Conglomerate and of the other rock-formations of the coal-field are well defined.

II.—Description of Tracks from the fine-grained siliceous mudstones of the Knoydart Formation (Eo-Devonian) of Antigonish County, Nova Scotia.[1]—By H. M. Ami, M. A., D. Sc., F. G. S., *of the Geological Survey of Canada.*

(Read May 13th, 1901.)

Ichthyoidichnites Acadiensis, n. sp.

Plate no. 2.

1897, *Protichnites carbonarius*, Fletcher, *(partim) Annual Report, Geol. Survey of Canada*, new series Vol. 2, p. 68 P.

These tracks are arranged in pairs and indicate an animal possessing bilateral symmetry with powers of locomotion and suspension in water without leaving a trail or mark of the body proper. They were evidently made by some fin or spine-like appendage attached to the body of the organism, which may have been that of an acanthodian or other early form of fish existing in the early Devonian lake, sea or estuaries of Nova Scotia.

There are eight pairs of tracks preserved on one slab showing seven completed strides, steps or series of advances. They consist of two more or less parallel linear depressions, which spread slightly anteriorly in the direction of progress or advance forward, accompanied posteriorly by two somewhat raised ridges or monticules, the result of the accumulation of the once soft fine mud or sediment by the fine or spine-like pointed appendage in the forward motion of advance. As preserved, the eight pairs of tracks indicate that at the time they were made the animal took a turn to the left and changed the direction of its course by an angle of thirty-eight degrees.

---

[1] Published with the permission of the Director of the Geol. Survey of Canada.

ICHTHYOIDICHNITES ACADIENSIS, N. SP.
(TO ILLUSTRATE PAPER BY DR. H. M. AMI.)

Face p. 330.

The impression or track made by the left fin or spine appears slightly in advance of that made by the right appendage in all the eight pairs preserved on the type specimen, which seems to indicate that the creature used its appendages in locomotion in a slightly alternating manner, striking the mud with the left appendage first. The average distance in advance of the left imprint or track from the right is between three and four *millimetres* measured in a direction at right angles to the course taken by the organism from the apices of the monticules.

The slabs on which these tracks are preserved consists of a thin-bedded, fine-grained, greenish and chocolate-red coloured, siliceous sandstone with numerous minute glistening scales and particles of mica along the divisional planes of stratification.

The following table is prepared with a view of giving the number of pairs of tracks preserved on the type-specimen, the exact measurements of the linear depressions or imprints made by the spine-like appendages as well as the distances between them, the relative size and distance between each and the different pairs of the monticules measured from their apices, together with the length of the stride:

MEASUREMENTS IN MILLIMETRES TAKEN FROM TYPE-SPECIMEN.

PAIRS OF TRACKS.	Length of left linear depressions	Length of right linear depressions	Greatest diameter of the left monticules.	Greatest diameter of the right monticules.	Distance between the monticules.
First pair..........	5.00 mm.	2.50 mm.	2.50 mm.	1.50 mm.	5.00 mm.
Second pair	5.50 mm.	1.50 mm.	2.50 mm.	1.50 mm.	4.00 mm.
Third pair	4.50 mm.	3.25 mm.	3.50 mm.	1.25 mm.	5.00 mm.
Fourth pair	4.25 mm.	1.50 mm.	2.00 mm.	1.00 mm.	8.00 mm.
Fifth pair..........	6.50 mm.	4.00 mm.	2.75 mm.	1.00 mm.	5.50 mm.
Sixth pair..........	4.50 mm.	3.50 mm.	2.00 mm.	2.00 mm.	7.00 mm.
Seventh pair........	5.00 mm.	3.75 mm.	2.50 mm.	1.75 mm.	5.50 mm.
Eighth pair.........	5.00 mm.	2.25 mm.	2.25 mm.	1.75 mm.	5.50 mm.

TABLE SHOWING LENGTH OF STRIDE, STEP, OR SPACE BETWEEN IMPRESSIONS MEASURED FROM THE APICES OF THE MONTICULES.

PAIRS OF TRACKS.	Between 1st & 2nd	Between 2nd & 3rd.	Between 3rd & 4th	Between 4th & 5th.	Between 5th & 6th.	Between 6th & 7th.	Between 7th & 8th.
Left	18.00 mm.	16.00 mm.	15.50 mm.	14.50 mm.	17.00 mm	15.50 mm.	17 50 mm.
Right	17.50 mm.	15.50 mm.	15.25 mm	16 50 mm.	17.00 mm.	15 50 mm.	17.50 mm.

It will thus be seen that the length of steps or space between the impressions are at comparatively equal distances, and in the neighbourhood of seventeen millimetres. The sixth and seventh pairs of tracks are the most normal in the series.

These tracks are unlike any recorded from North America, and the name *Ichthyoidichnites Acadiensis* is suggested with a view of indicating the locality where the tracks were found, as well as the possible organism that made it.

Locality and Horizon :—A few yards below the earth and stone bridge over the McArras Brook along the shore or post-road near the schoolhouse at McArras Brook, P. O., Antigonish Co., Nova Scotia; in the dark red and drab, evenly-bedded, fine-grained siliceous and jointed mudstones of the *Knoydart* formation of early Devonian (Eo-Devonian) age, supposed to be the equivalents of the Lower Cornstone or old Red Sandstone of Herefordshire, England. [Between stations No. 5 and No 6 of Mr. Hugh Fletcher's section][1] and a few feet below the bed of tufaceous rock holding *Pteraspis, Cephalaspis and Psammosteus.*

Collector :—Mr. T. C. Weston, F. G. S. A. *Date :* August 6th, 1886. The specimen is now deposited in, and forms part of the collection of Knoydart fossils in the Museum of the Geological Survey of Canada.

Geological Survey of Canada,
Ottawa, April 19th, 1901.

[1] See Can. Rec. Science, Vol. viii, No. 5, p. 303, Montreal, January 15th, 1901.

III.—On Drift Ice as an Eroding and Transporting Agent. —By W. H. Prest, *Bedford, N. S.*

(Communicated 14th January, 1901.)

Introductory.

In the following notes, although I may not be able to bring forward any new facts of importance, I can at least add my testimony to that of those who have studied in the same line.

Having had an opportunity, while in Labrador, during the the past summer, of observing the action of drift ice as an eroding and transporting agent, I submit the following, prefaced by a few notes on the elevation now going on there.

On the north-east coast of Labrador, where my observations were made, the action of purely drift ice is more marked than anywhere else in the same latitude; and during the melting and transportation of the northern ice there is abundant opportunity for gathering information relating to the subject.

During the short Arctic summer the northern ocean pours forth a tremendous stream of ice. This stream, borne southward on the bosom of an Arctic current, sweeps from side to side, the sport of ever-changing winds, like the tail of a gigantic kite. Sometimes this stream or tail is swept out into the Atlantic, then against the rock-bound coast of Labrador, and often through the Straits of Belle Isle into the Gulf of St. Lawrence. The field- or pan-ice inshore, and the bergs in deeper water, here exhibit their capabilities under many varying conditions. Their action in deep and shoal waters, or on steep shores and submerged ridges, and their power as erosive and transporting agents, can be seen to advantage. There are several reasons why this coast should be considered the best known station for the observance of the effects of drift ice :—

1st. Its convenient nearness to civilization and the source of ice supply.

2nd. The direct and continuous action of ice upon a coast line nearly 1000 miles in length, and reaching from the source of supply almost to the limit of its drift.

3rd. The phenomenon of a rapidly rising coast line.

My enforced detention here by ice blockades drew my attention to these advantages for study and evinced the close connection between present conditions in Labrador and the later Pleistocene of the Maritime Provinces.

General Appearance.

The shore along the northern side of the Straits of Belle Isle is generally sloping, sometimes steeply so, rising at a short distance into high rounded or rugged hills. On these slopes the sea has written both history and prophecy, the record being marked by ancient shore lines. Here and there, as at Henley Harbor, bold cliffs line the shore and give variety to what would otherwise be an intensely monotonous waste of rock and moss. North of Battle Harbor the mountains approach the shore more closely, and being of a rugged outline and pierced by deep inlets, and often faced with precipices, present a wild and forbidding appearance. Along the whole outer coast, for nearly 100 miles north of the straits, a tree is not to be seen. The islands especially are barren and storm-swept to a degree that makes this coast more like perfect desolation than any other place in the same latitude. The fine deep harbors, however, partly compensate for the extreme desolation of their surroundings. Thence, onward to Hamilton Inlet, the coast is lower; and long gentle slopes run up from the sea, and the hillsides are often clothed with trees. The headlands and islands, however, continue bare, even moss being absent on some of the most exposed points and headlands. Such a thing as tillable soil, as we know it in Nova Scotia, I have not seen on this barren shore. Only on the flowage plains of the large rivers is there any soil worthy of the name; and on this ice-scoured shore its presence would be strange indeed. There, since the last glacial epoch, through

subsidence and elevation, the annual stream of Arctic ice has washed and scoured until every vestige of lighter material has been slowly but surely swept into the ocean.

Elevation of Land.

A condition that has influenced, somewhat, ice erosion in Labrador, is the elevation now in progress in that region. The resulting raised beaches and escarpments on the Straits of Belle Isle and elsewhere, are the most marked of the minor features of that coast. These evidences of former subsidence extend from the valley of the St. Lawrence around the whole coast of Labrador and Arctic America. The subsidence reached its greatest development in the St. Lawrence Valley and on the shores of Hudson Bay, where ancient shore lines are seen at heights of 600 to 875 feet The highest of the shore lines of south-eastern Labrador are between 150 and 180 feet above the sea level. They are four to seven in number, of which the second is the most prominent and shows the longest period of rest for the elevating agencies. Then follows the third, while the fourth and fifth are barely traceable in some places. These escarpments do not mark the full number of pauses in elevation on the Labrador coast, but only the principal ones. Mr. Low, of the Canadian Geological Survey staff, noticed 14 small terraces within a few yards at the mouth of the Northwest River, Hamilton Inlet. This process is also shared in by the west coast of Newfoundland, the evidence of which can be seen almost to Cape Ray. On this coast, however, there appears to be a pivot or centre of oscillation, as the south coast of Newfoundland is sharing in the subsidence now general from Prince Edward Island to New Jersey.

The rise in Labrador does not seem to have been gradual, but to have proceeded in a series of pulsations which, apparently, are still going on. In fact the recent rise of "Mad Moll," a ledge of Sandwich Bay, seems to indicate the present as another period of elevation. The oldest inhabitants claim to remember when this ledge was visible only at low water. Now it is seldom

covered even by spring tides. The first appearance of "Mad Moll" was a noteable event in the life of the preceding generation. The north or main passage of Sandwick Bay, not many years ago navigable for small vessels, is now impassable for anything but boats At Mullen's Cove and Black Island, raised beaches are seen composed almost entirely of mussel shells, some of them unbroken and clean as if thrown up yesterday. These shell deposits are of course seen only in the more sheltered coves where they are protected from the grinding action of drift ice. The rate of elevation here indicated is considerably greater than some recent estimates, and I would like to hear new evidence on this point.

One noticeable point is, that the hillsides above the escarpments show the same smooth and storm-swept appearance as between and below them, as if they had been subject to the same influences and wear by drift ice. Whether the upper escarpment marks the limit of subsidence or not, the natural inference seems to be, that a gradual and regular elevation of a sloping exposed surface, especially when comparatively rapid, leaves no traces of ice action. The retiring sea and ice washes off and carries to lower levels the debris formerly covering the solid rock. Only when the downward movement is arrested, does it form escarpments and beaches, and the fact that no escarpments nor beaches are seen above the highest shore line is no proof that the sea level had not once been higher. Neither on nor around any of the hills near Battle Harbor and Cape Charles (some of which are 700 feet high), is there any sign of glacial debris; and had it once been there it does not seem possible that either land-slides or fluvatile action could have banished it so thoroughly from both hill and valley.

The raised beaches are seen only in sheltered bays where not exposed to the possibility of being swept away by water or landslides from above, or intense ice action from the sea below.

A. C. Low, from observations on Hudson Straits, supposes that part of the coast to have come to a standstill. But on the Straits of Belle Isle the last escarpment seems to be rapidly advancing beyond the level of mean tide.

Drift Ice as an Eroding Agent.

A great part of the erosion now acknowledged as due to other causes has often been ascribed to drift ice. Formerly great stress was placed on erosion by drift ice, particularly by icebergs as in opposition to drift ice. No doubt some erosion was actually effected, but that its traces in the form of striations are still retained above the sea level is very doubtful.

In the official reports of some of the Canadian Geological Survey staff, and also in the writings of other geologists, we can trace a gradual conversion from the old theory to the new, in which ice-action is confined almost solely to the polishing out of former inequalities and striæ In some of the latest reports, erosion by drift ice is considered possible only under exceptional circumstances. The cause is often proved by circumstantial evidence, or entered with a mark of interogation. It is also admitted that only where a low point or ridge is exposed to an ice jam forced over it by a storm, is striation possible, and then only when the ridge can also be reached by stones to act as graving tools.

Some of the results of my observations on ice action are as follows: Ice action on a steeply sloping shore occurs with an onward rush of water carrying immense masses of ice 5 to 15 feet in thickness. When reflex action begins the ice is poised for a few seconds on the rocks until the water drains partly away. Then, being deprived of support, it slides back with a tremendous plunge into the next advancing wave, dragging with it into deep water such rock fragments as it may have been able to reach. And what is very important, these rock fragments are never carried forward again; for the next wave lifts the ice pans forward, high over every obstruction. The scoring, if any, in this case is done while the ice mass is sliding into the water with stones beneath it, as it exerts little downward pressure when rising with the rush of water. Where exposed to the Atlantic swell, ice pans 15 feet thick and 50 feet in diameter are often carried forward through a perpendicular distance of

25 feet, sweeping everything clean before them. The result is, that in very few places in Labrador are there any boulder ridges such as we see in Nova Scotia. Therefore, these latter can hardly have been the product of exactly the same conditions as are present in Labrador.

Ice action on ridges, shoals and low points, consists of an onward rush of ice as described above, but the ice in front is left poised on the ridge until pushed forward by other ice masses brought in by succeeding waves. Loose stones moved on those nearly flat or slightly sloping surfaces are nearly always rolled, and not pushed. But any stones caught beneath the ice, act as gravers and score the rock over which they slide. Striæ made by stones in such a position are easily distinguished from the straight scratches left by retiring ice on a sloping shore, and also from striæ of acknowledged glacial origin. Such striæ are sometimes curved owing to the swinging of the ice mass and consequent change of course of the graver beneath. But they often form a furrow of which different parts run in different directions. This latter is owing to irregular and repeated pushes from ice in the rear.

Another form of marking is made when a large quartz or granite boulder is rolled on a soft slate bottom. It then produces a series of notches and irregular scratches.

But it must not be forgotten that the first ice thrown up in the spring usually cleans off the debris previously gathered, after which it is exposed to months of continuous wear by ice, sand, and water. And should such striæ be covered by a layer of debris, this is certain to be worked over to a great extent before being swept into deep water, or thrown beyond the reach of the highest tides. Therefore, the preservation of striæ in such positions seems to be well nigh impossible, except on the inner side of the ridge or point, where its formation is extremely doubtful.

There are, however, two classes of marine striæ which are not usually polished out.

To one class belong the scratches caused by the expansion of harbor ice holding large stones which are pushed up from shoal water. These are most prominent in the best protected positions, where it appears impossible for glaciers or drift ice to act.

The other class of marine striæ is formed by large boulders lying usually at high watermark, and which have been rolled down from frost-shattered cliffs near by. They are pushed back by ice jams or by ice hurled against them in a storm, and move a foot or a few inches at a time. These striæ are partly protected from obliteration by the boulder itself.

In regard to the question of erosion by icebergs, the first point to be considered is whether bergs carry stones in positions suitable for eroding.

Observers in the far north, as well as those who have examined glaciers in more temperate latitudes, maintain that debris falls into cracks, or is lodged on the surface of those ice masses and are then carried to sea when the bergs are detached. But it is plain that stones attached to the sides and bottoms would melt off during their long voyage, and this contention is supported by much negative evidence. Although I saw many overturned bergs I saw no stones attached. I therefore feel compelled to fall back on the theory that bergs striate the sea bottom only by bringing their great weight to bear on loose rocks. Should such striæ have been formed before the old shore lines were raised to their present positions, they could not possibly have emerged above the polishing influence of the field ice. Being formed only in the positions afterward exposed to the wear of pan ice, I am thoroughly convinced that such a phenomenon as striæ by ice-bergs does not exist above the sea level.

A rising coast as in Labrador, exposes a well worn rock bottom, smoothed by ice action during the preceding subsidence; and in an exposed position all protecting debris is speedily washed into deep water, and all signs of berg erosion obliterated.

A sinking coast carries its striæ with it, if such striæ can be retained long enough to get below the intense ice action seen in Labrador.

Finally some of the most exposed situations show no signs of abrasion by floating ice. Such are the Magdalen Islands and Labrador, although in the latter place I have made special search for such evidence. And though sea-borne ice may be counted on as an eroding agent of moderate possibilities, as a factor in the production of existing continental striations it can be allowed only a very minor position, if indeed it cannot be altogether eliminated.

Transportation of Debris by Sea-borne Ice.

It has been maintained by some of our foremost geologists, that the Grand Banks of Newfoundlaand as well as the banks off the Nova Scotia coast are chiefly of sub-Arctic origin. Concerning this, questions like the following may arise in the mind of an inquirer: If so, where are the moraines, the certain results of glacial transportation from the provinces mentioned? What has become of all the debris carried from these provinces when the river valleys were excavated, and when they stood at a higher level than now?[1] Also, is the quantity of material brought south equal to the formation of such immense accumulations?

I do not know that any very extended observations have been made to find out to what extent this debris is being transported. Several observers in the polar regions have noticed large quantities of loose stones and earthy matter on pan ice or attached to icebergs, notably, Scoresby, Wilkes, and Sir John Ross. Based on these statements, many investigators have given great prominence to the transporting power of Arctic ice, and write as if earth-laden ice was a common sight off the Newfoundland and Labrador coasts. But of those who have given their time to the question, I know of none who have made actual observation among the drift ice the basis of their theories. Only by getting a fair idea of the quantity of debris remaining on the ice toward the close of its long voyage, can a just opinion be given of its capabilities as a transporting agent.

[1] See papers by W. H. Prest in Transactions of N. S. Institute of Science, 1891-92, page 143; 1895-96, page 153.

I think that a great mistake is made in making no allowance for the melting of drift ice by water and air during its 1000 or 2000 miles journey to the temperate zone. When we reflect that icebergs 300 feet in height are common in the Arctic regions, and that very few of these are seen off the Newfoundland and Labrador coasts, the waste must be enormous. Many thousand tons of ice from the exterior of the bergs, containing, of course, the greater part of the debris, have been dissolved by air and water or have been washed away by the waves and surf of these stormy seas near their starting point. Icebergs, of which I saw several hundred from 40 to 200 feet high, were washed as clean as surf and melting water could wash them Overturned bergs showed the same cleanly condition. Icebergs excavated to a dept of 100 feet by wave-washed caverns showed the purest and most beautiful blue, untinged by the slightest impurity. This melting process which is done chiefly by the sea, is so rapid at the water's edge that before they reach the Straits of Belle Isle many of the smaller bergs assume the form of gigantic umbrellas and finally topple over. These ice umbrellas, by the way, are one of the most fantastic sights of the northern seas. Often the caps are 30 to 60 feet in diameter with a stem 3 to 6 feet thick, and 5 to 15 feet high. They do not appear to be always perfectly poised, but the immense weight of the lower portion keeps the upper part erect. And this ice is always free from impurities.

In regard to field or pan ice, I have examined it from high hills with a powerful glass, and have chopped my way through it in an open boat, but have very seldom seen a discoloured pan.

The only ice-borne debris worthy of mention is that frozen to the bottom of field or pan ice while grounded on shoals at low tide. Sand or mud is frozen to the bottom; then at high tide this is covered by a layer of pure ice, which process is often repeated. Though the probabilities are that nearly all shoal-water ice from the far north will be inter-stratified with debris yet the fact is that an exceedingly small part of what came under my observation was thus stratified. Though watching

for many days the upturned edges of the ice floes as they were driven on shore, I saw very few with debris thus frozen in. The deposits seen by me were often very unequally laid on, and frequently absent near the bottom, where they naturally should be. Sometimes an overturned ice pan showed sand, but for the old idea that field ice obtained most of its debris from overhanging precipices I could find no evidence.

Conclusions.

After having spent two months surrounded by ice fields, and often beset on all sides with its difficulties, I have concluded that very little of all the debris seen on the ice in polar regions ever reaches the latitude of the Straits of Belle Isle, and also that the Grand Banks are only receiving a fraction of the amount of material formerly supposed. Consequently the Banks from Newfoundland westward are almost solely the products of the period of the greatest extension of ice erosion when the source of the debris was our own provinces. It appears, therefore, that those submerged banks are but the marine representatives of the sand dunes and flats of New Jersey, Long Island, Cape Cod and other places, and are principally the natural result of greatly prolonged wave action on true glacial moraines; with, however, this difference, that while the western deposits were formed almost solely from the detritus from Apalachian and local glaciers, the eastern have been added to in the later Pleistocene by an Arctic current. The paucity of transported material on the ice in the latitude of the Straits of Belle Isle convinces me that it takes but a short time for storm and surf to clean thoroughly all the ice brought down by the Greenland current. Therefore, we cannot look farther north than Eastern Labrador and Newfoundland for the source of any debris that may have been added to the Grand and Sable Island Banks. In regard to Sable Island, a recent paper by Dr. A. H. MacKay, on a fresh water sponge found there, may furnish food for speculation as to its origin. This, however, I do not think would affect my conclusions. The sponge, if not an evolution from a marine

form, may have been transported from the continent in a block of river ice.

As to the period of this age of transportation, it probably coincided with the retirement of the continental ice-cap and the elevation of Canada and the Arctic regions. Before this, the glacier ice was shed directly into the ocean in front. The elevation of the polar sea-bottom probably greatly strengthened the otherwise weak Greenland current, thus turning the debris-laden Labrador and Newfoundland ice to the southward.

In connection with this, the beautifully precise theories of oceanic currents do not seem to apply fully to the Labrador and other northern currents, as the constant outpouring of polar waters is not met by an equal inflow. Even the most northern branch of the Gulf Stream is stopped at Spitzbergan, and returns by way of the east coast of Greenland, apparently forced to do so by the current which carried the "Fram" in a southwesterly direction. The rapid rise of the north Polar regions seems to contribute largely to all the currents which flow outward from that point. The great depth of the Polar ocean as proved by Nansen would supply the surplus water needed, through the constant rise of its bottom.

With the increasing amelioration of the climate of the north temperate zone, came the gradual retirement of the Labrador glaciers and the consequent cessation of the supply of the building material to the Newfoundland banks. Therefore, the transportation of sea-borne detritus has been gradually lessening owing to the retirement of the source of ice supply, in spite of the fact that the power of the Greenland current had been probably increasing until it reached its maximum a few centuries ago, when the flow of ice to the southward was much larger than it is now.

The building, or increase of submarine banks, is doubtless still going on, but the work in now confined to the neighbourhood of Greenland and northern Labrador.

How long this ice-bearing Arctic current will continue to flow, must depend largely on the rise of the land in the polar

regions. The narrow channels through which the water flows from the north and northwest have been gradually getting shallower and narrower, and should the present elevating process continue the force and bulk of this current must be greatly lessened, if not altogether extinguished.

There is much room for investigation in this subject; but circumstances compel me to leave to my more professional brethren the work of proving or disproving fully the conclusions I have arrived at.

IV.—Stigmaria Structure.—By Henry S. Poole, F. R. S. C. F. G. S., &c.

(Read March 18th, 1901.)

The specimen of Stigmaria here exhibited is from the Coal Measures at Stellarton, and from a fireclay bed between two of the working coal seams. The original fragment, about 9 inches long and 3.5 by 2.25 in cross-section, was given to the Geological Survey Museum with a preferred right to a section should the piece ever be cut. This was done on the advice of the Director. the late Dr. Dawson, who also sent another section to Mr. Kidston of Stirling, Scotland.

The special interest in the specimen, lies in the exceptionally well preserved condition of the heart or medulla due to infiltration, the whole root having been converted into clay ironstone. The piece here shown presents a cross section only of the beautifully preserved scalariform tissue of the medulla which is placed below the centre of the root and nearest the concave underside. Mr. Kidston in his acknowledgment to Dr. Dawson, remarked that the section was one of considerable interest from a botanical point of view, shewing more numerous and finely radiating wedges of vascular tissue than other stigmaria roots he has lately been studying.

Stigmaria, when first found, were considered a distinct genus but are now known to be but the roots of Sigillaria. The late Mr. R. Brown of Sydney Mines, Cape Breton, found in the cliffs near the pits a tree trunk that clearly showed the passage of the Sigillaria stem into the Stigmaria roots, and similar specimens have been found elsewhere.

The Sigillaria, Mr. Carruthers describes as consisting of a central cellular pith or medulla surrounded by a sheath consisting wholly of scalariform vessels, the whole enveloped in an

external cortical mass of cellular tissue. The medullary sheath is perforated by meshes for the passage outwards of the vascular bundles which go to the aerial appendages (the leaves and branches), but there are no true medullary rays. Hence he classes the Sigillaria as Cryptogamic and Lycopodiaceous.

The external surface of Stigmaria is without the vertical and parallel fluting between the pits or shallow tubercles distinctive of the Sigillaria, and in this particular specimen the pits are rounded, depressed and widely separated and not sharply defined. No rootlets were attached. When found the fire-clay bed had weathered away from the specimen.

The internal structure exhibits a central pith surrounded by a sheath of scalariform vessels, the whole enclosed in a cellular envelope. Dr. A. H. MacKay, our President, kindly undertook to examine this specimen, and I am glad to be able to append his description with reproductions of photographs of magnified portions of the section.

I would merely add that it is now believed that such piths as this specimen illustrates have, when separated from their envelope, given rise to fossils classed as Sternbergia, which are described as comprising cylindrical transversely marked casts of pithy cylinders of other plants, belonging chiefly to conifers, but referable also to sigillaria.

Dr. MacKay's Description of the Section.

The section is transverse, about 21^{mm} thick, black, with infiltrations of brown to white in some crack-like lines, and is polished where cut. This polished black surface (clay ironstone) can be scratched by the point of a hard steel knife, but does not effervesce under a drop of hydrochloric acid. The whitish infiltrated lines referred to effervesce as if calciferous.

The contour of the section is an irregular oval with rectangular axes respectively about 95^{mm} and 60^{mm}. An approximately concentric crack-like line partly infiltrated with whitish material runs around more than two-thirds of the periphery, about 4^{mm} from the edge, suggesting an exterior bark layer.

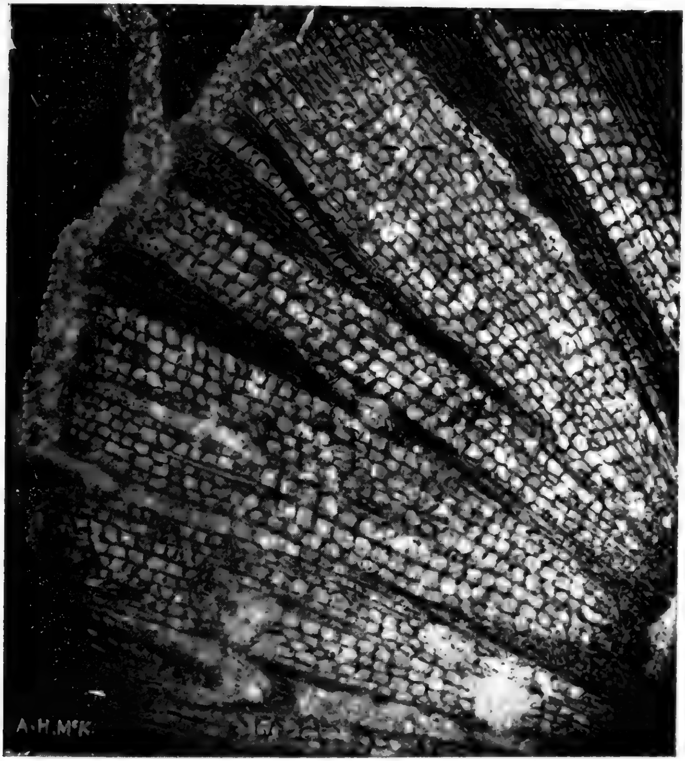
Photograph by Dr. A. H. MacKay.

TRANSVERSE SECTION OF VASCULAR CORE OF STIGMARIA.

Magnified about 3½ diameters.

(TO ILLUSTRATE PAPER BY MR. POOLE.)

Face p. 346.



Photograph by DR. A. H. MACKAY.

TRANSVERSE SECTION OF VASCULAR BUNDLE FROM CORE OF STIGMARIA.

Magnified 16 diameters.

(TO ILLUSTRATE PAPER BY MR. POOLE.)

Face p. 346.

Eccentrically placed within the dark and apparently structurless surface, about 30^{mm} from one side and less than ten from the opposite side, is a nearly circular band of over thirty slightly wedge-shaped bundles of rectangular cells, surrounding a structureless central circular area like the rest of the section surface about 11^{mm} in diameter.

The bundles of cells are in radial direction from 6 to 7^{mm} in length and from less than 1 to about 2^{mm} in breadth, containing from 5 to 15 radial rows of cells, each having about 40 or more rectangular cells in a row. The bundles are separated by the uniform black material within and without the ring of bundles of cells, each bundle being separated by a space of more or less than 1^{mm}.

The lumen of the cell is white (a calcium carbonate infiltration), rectangular, 100 microns by 175 being a common size. The cell wall is black and thin, less than 10 microns thick. The smaller cells are often nearly square, 50 to 75 microns, but the tendency is to a greater length radially than in breadth. Cells 125 microns by 200 are the largest commonly found. The cells become larger generally, as they recede from the centre, and the widening of the bundles in the same direction is also caused by the appearance of interstitial rows of cells, so that the bundle has a few more rows of cells across the wider than across the narrower end, as a rule.

V.—THE STAR-NOSED MOLE *(Condylura cristata)*—ITS BREEDING HABITS, ETC.—BY WATSON L. BISHOP, *Dartmouth, N. S.*

(Read March 18th, 1901.)

The Star-Nosed Mole occurs from Nova Scotia to Indiana and northward, but as far as I am aware is not anywhere abundant. The soil where it is most commonly found is sedimentary and quite near to water. Intervale or meadow land is almost invariably selected as its place of abode. In such a locality, during the spring and autumn months, little mounds of black soil are thrown up in zig-zag rows marking the course of its subterranean roadways.

To dig one of these little fellows out of the ground is no easy task, although the holes are quite easily found and readily followed; there are so many angles and turns that one's labours are seldom rewarded with as much as a glimpse of the little creatures.

On May 22nd, 1890, while having some apple trees planted, I had the good luck to find a nest containing four of the young.

The locality where the nest was found was two miles south of Kentville in King's County, Nova Scotia. The land had been cleared of small forest trees several years before and had grown up with grass and was mowed every year.

The particular spot where the nest was found was a little hillock or cradlehill which had been formed apparently by a tree having been blown down. When the roots had rotted away a small dry mound of soft black sedimentary earth was formed, and in this the nest was built. This mound was high enough to be out of reach of storm-water during wet weather.

The excavation containing the nest was ten inches below the surface, and was made in a circular form, seven inches in diameter. The nest was built of old dry grass, and was very

compact aud neatly made. Although the mound contained a complete network of roadways, no earth was thrown to the surface within ten feet of the nest.

The young were probably ten days old, the fur just beginning to start, which gave the skin a dark brown colour. They were at once taken and preserved in spirits, and have since been presented to the Provincial Museum at Halifax (accession no. 149.)

VI.—Recent Developments with the Calyx Drill in the Nictaux Iron Field.—By D'Arcy Weatherbe, C. E, *Minss Dept. of N. S., A. M. Can. Soc. C. E.*

(Received August 20th, 1901.)

Introductory: Geological and Historical.

It would be as well perhaps for the benefit of those unacquainted with this district to preface the following account with a few descriptive remarks on its general geology. The measures which accompany the ferriferous deposits here are generally considered to be of Lower Devonian age. The area with which the operations herein to be described deal, may be said to be bounded as follows:—On the north by the Triassic red sandstones which underlie the contemporaneous trap diorites of the North Mountain range; on the west by a band of granite extending northerly, partly across the valley between the North and South Mountain, and lying about a mile west of the Nictaux River. This latter is not strictly speaking a geological boundary, as the same veins of ore have been followed west of the granite, and are possibly overlain by it. On the south along the summit ridge of the South Mountain begins that enormous mass of granite which extends half way to the Atlantic Ocean, and effectually prevents prospecting in that direction. Towards the east, the boundary, as far as these veins are concerned, may be said at present to be indefinite, though they can be traced several miles east of the Nictaux River.

Until 1891 little practical attention had been devoted to the prospecting of the region, and with the exception of the early attempts at mining and smelting, no development of any importance had been undertaken. In that year (1891), the Torbrook Iron Co. commenced operations on a vein of red hematite

averaging about 9 feet in thickness and showing from various tests the following analyses: *

Metallic Iron.	Silica.	Phosphorus.	Sulphur.	Lime, Mang. and Alumina.
52.44	11.00	1.66	none	8.64
60.72	10.28	.17	trace	......
59.00	12.86	trace	trace	trace
61.38	26.50	.....	.....	......
47.00	10.12	1.08	trace	5.30
55.74	14.97	trace	trace	......
74.59	17.21	.18	.23	......
11.57	5.93	.17	.08	......
57.93	......	.16	.09	.....
59.86	......	none	.36	......

From which it will be seen that though rather a silicious ore, it is low in sulphur and phosphorus, and high in metallic iron.

The vein dips at an angle of about 80° to the south at the surface, and flattens to 45° at a depth of 350 feet (as proved by the workings of the Torbrook Iron Co.), and the general strike throughout the district is about N. 62 E.

This company in 1896 completed their contracts, and no immediate market offering elsewhere, they closed their mine, after having shfpped in the five years 135,000 tons of ore to the Londonderry and Ferrona furnaces. When closed down, the mine showed large quantities of good ore in sight, and a vein from 6 ft. to 12 ft. in thickness.

About 65 feet to the south of this vein lies another deposit of red hematite, called from its fossiliferous character the "Shell ore vein," which from several analyses runs about 54% metallic iron. This vein measures about 6 to 9 feet in width. The fossil shells occuring in this bed consist of varieties of *Spirifer*, *Strophomena*, *Atrypa*, *Avicula*, *Bellerophon*, etc., etc.

North of the vein worked by the above company, and about a mile west of their mines, another vein five feet in width has been found, which at this point presents in common with most of the iron deposits in the district, different characteristics, as it is

*These analyses are from a paper on the Iron Ores of Nictaux, by Dr. E. Gilpin, Nova Scotian Institute Science—session 1894-95.

found further to the west. The most marked of these changes is the magnetic property probably imposed by the metamorphism nduced by the proximity of the granite. On the abandonment of the mines, the district remained for some years undisturbed, a state from which it was aroused early in 1900 by the energetic prospecting operations of a syndicate of Halifax gentlemen, who it is understood control practically all of the ground described above, which may now under the light of recent developments be fairly termed the Torbrook or Nictaux "synclinal."

Description of Drill.

A few words may not be amiss as to the parts and working of this drill. It cuts a 4 or 5 inch core as desired, and the satisfactory results attained may be judged by the fact that the writer recently saw several complete unbroken cores 5 inches in diameter and measuring nearly 7 feet in length. An idea of the valuable record secured by such a core is gathered from the fact that they contained slate, quartzite, and magnetite with crystallized geodes of quartz and stringers of calcspar, all dipping obliquely across the vertical axis of the core.

The apparatus consists of an upright boiler and compound engine (about 12 h. p.), drum, chain and sprocket wheels, driving shaft and bevel wheel, rotating device, drill head and hoisting derrick.

The drill proper consists of the "cutter," a hollow steel cylinder with peculiarly shaped teeth at the bottom, set alternately at approaching and diverging angles with its axis. This is screwed to the bottom of the core barrel which is simply an iron tube of the same diameter into which the core passes when cut

In hard rock, instead of the cutter and core-barrel, the shot bit and barrel, a fifteen foot steel cylinder of the same diameter is used, and under its edges are fed chilled steel shot, and the friction caused cuts the core.

The drill rods are of 3 in. hollow steel, and are screwed by means of a "reducing plug" into the upper end of the core-barrel.

The "calyx," or as it has been aptly termed the "chip barrel," is also a tube of the same diameter as the core-barrel, and surrounds the lower drill rod. It rests on the reducing plug, and is open at the upper end. Water being fed down the drill rods, passes out at the bottom of the hole, and is forced up between the rock wall and the core-barrel and calyx. This water naturally carries with it the sand and rock chips formed during the process of cutting the core, until when the top of the calyx is reached, the pressure is lessened by the space being increased, and the chips fall into the calyx, thus forming a perfect, though inverted record of the formation passed through. To the top of the pulley-head is screwed the feed pipe, and to the bottom a square rotating rod which is screwed to the highest drill rod, and fitting through the rotating device is held by a clutch, and thus the motion is given to the drill.

Method of Operation.

After setting up the drill, the first operatiou is to insert the pipe-casing—an iron tube slightly larger in diameter than the outside of the core-barrel—through the loose surface material, and a short distance into the bed rock.

This is done by placing on top of the pipe-casing a wooden block (about 12″ thick), and using a pounder worked with the hoisting gear. A heavy, flanged iron pipe, weighing probably 400 lbs. has been used for this purpose with success. Great care must be taken to keep the piping plumb, as mistakes at this stage will probably necessitate abandoning the hole.

Another error that is sometimes made, and which by experience has been corrected here, is the digging of a shaft in which to sink the casing. Even with the greatest care being exercised, it is found that though the shaft outside the pipe may be filled and thoroughly tamped, there is great liability of the hole being blocked, and of the top of the calyx catching on withdrawal of the drill.

Having successfully placed in position the casing, the cutter, and core-barrel, or if the rock is very hard, the shot bit is intro-

duced, and the engine set going. When a sufficient depth s reached the calyx chip-cup is coupled on and the rods successively placed between the chip-cup rod and the square rotating rod.

It occasionally happens that a rod-coupling breaks at a depth below the surface. The portion of the drill above the break is withdrawn, and a threaded cone called a "tap" is inserted on the end of a rod, and screwed into the broken coupling and the bottom portion is withdrawn.

When the core breaks accidentally it immediately becomes known by the riding motion of the drill, and the drill runner should be on the alert at such a time to prevent much weight being placed on the drill head, as the couplings at once become endangered.

When it is desired to withdraw or break a core, the motion is stopped, and a heavy flush of water is forced down the drill rods, coarse gravel being at the same time fed with it. The gravel becomes jammed between the core and core barrel, thus holding the former firmly; the pipe wrenches are now placed on the square rotating rod at the top, and with the aid of the engine a sharp twist is given to the drill, and the core breaks.

In the event of a piece of the core splitting off below, and it being found impossible to re-insert the cutter or shot-bit, the chopping-bit, a steel head like a blunt chisel is placed on the end of a rod, and repeatedly dropped into the hole, breaking up the offending piece of rock.

As little water as possible is used with the shot, as it tends to waste by depositing it in the chip cup, or bringing it up to the surface. On the other hand, with the cutter in softer rock all the water possible is used.

Records of Boring.

Boring was commenced on October 13th, 1900, on the "Berteaux" Farm, at Torbrook, the drill being under the charge of Mr. Burnett, the drill company's expert.

A position was chosen for the first hole at a point about 12 feet south of the hanging wall of the "Shell Ore" vein. This vein, as mentioned, has been proved for a long distance east and west, and the dip at this point was supposed to be about 85° to to the south. Thus the vein should have been tapped at a depth of about 137 feet from the surface; but this, as will be shown by the records given below, did not prove to be the case.

In this first hole the following section was exhibited:

No. 1 Hole.	
Material.	Feet.
Detritus, clay and loose boulders........................	12
Reddish shale (soft and friable)..........................	48
Total....................................	60

At this depth, 60 feet from the surface, the hole was abandoned in consequence of its being blocked by boulders getting jammed in it under the metal pipe casing, which it seems had not been properly inserted below the surface of the bed rock. A shaft had been dug for its insertion.

The next hole, 15 feet to the eastward of no. 1, was the same distance from the supposed position of the hanging wall. Owing to a delay in the arrival of piping, it was not commenced until Oct. 26th. From this date it was sunk continuously till Nov. 21st, when a depth of 201 feet was reached.

The following section shows all particulars with regard to the boring:

No. 2 Hole.

Date.	No. of Hours of Boring.	Material.	Feet.
Oct. 26 ..	1	Red Shales	4
" 27 .	$3\frac{1}{2}$	" " and blue slate	17
" 29 ..	$4\frac{3}{4}$	" "	22
" 30 ..	$5\frac{1}{4}$	" "	24
" 31 ..	$6\frac{1}{2}$	Blue slate	19
Nov. 1 ..	$7\frac{1}{2}$	Hard broken slates with quartz	7
" 2 ..	8	" " " " "	6
" 3 ..	5	Very hard blue slates and spar stringers ...	6
" 5 ..	10	" " " "	$5\frac{1}{2}$
" 6 ..	$8\frac{3}{4}$	" " " "	10
" 7 ..	8	" " " "	7
" 8 ..	9	" " " "	7
" 9 ..	10	" " " "	6
" 10 ..	$9\frac{1}{2}$	" " " "	7
" 12 ..	$8\frac{1}{2}$	" " " "	6
" 13 ..	$8\frac{1}{2}$	" " " "	$5\frac{1}{2}$
" 14 ..	$9\frac{1}{2}$	" " " "	7
" 15 ..	10	" " " "	$6\frac{1}{2}$
" 16 ..	9	" " " "	$5\frac{1}{2}$
" 17 ..	9	" " " "	6
" 19 ..	$14\frac{1}{2}$	" " " "	13
" 20 ..	6	" " " "	4
Total ...	$171\frac{3}{4}$		201

It will be noticed how the rate of boring decreased when the drills left the soft shales, and entered the hard blue slate, and although not shown in the section, bands of quartzite were also met with. As seen by the record the cores would seem to show that the vein had feathered out into the shales or that the angle of dip was much more nearly vertical than at first assumed. In support of this latter theory it must be stated that the cores showed the dip of the rock to be practically vertical throughout.

The drill was now moved over to a position 12 feet to the north or actually on the hanging wall of the vein, and No. 3 hole was commenced on Nov. 26th. It should be mentioned that Mr. Burnett (the Drill Company's expert) left towards the end of October, and Mr. Phinney took charge of the drill on

behalf of the Government. The drill was finally drawn from this hole on Dec. 27th, after operating about 396 hours.

No. 3 Hole.

Material.	Feet.
Surface clay and boulders	10
Slate ond soft shales	3
Red shales with spots of spar and hematite	13
Blue slate and spar (very hard)	3
Red shale (hematite in spots)	13
Blue and red shale (hematite in streaks)	14
Soft red shale (hematite)	30
Slate and brownish ore	37
(Hematite with red shale)	27½
Brown ore, shsle with spar (very hard)	11
" " blue and red shale (hard)	19½
Red and brownish ores	3
" " " and slate	28
Brown ore and slate	15½
Softish shales showing spar stringers	102
Total	330

Ou examining the record above, it will be seen that the drill encountered ore from a depth of 13 feet at intervals down to 228 feet. At the same time it is a fact that no solid vein of any thickness was passed through in this hole, though the ore actually brought up iu the core-barrel appeared to be of good quality, and to run high in metallic iron.

Unfortunately it is a disadvantage of the large sizes of this drill that with its present arrangement of high top gear, it cannot be manipulated successfully at an inclination to the vertical, and the results of this hole leave one in considerable doubt as to whether anything of value has been proven here.

Owing to a peculiarity of the strike of the measures in this part of the district, it appears that they are subjected to a series of twists, or that short faults occur at intervals, throwing the portions affected to the south, when followed in a westerly direction. It may be therefore, that this hole has been sunk

exactly at one of these points where the strata would probably be much distorted and broken. However, be that as it may, it will be admitted that the following attempts on the part of the operators have proved eminently successful, not only in establishing the fact that large bodies of ore exist; but in assisting to prove that the formation here is a true synclinal basin.

The position for this hole was chosen after some deliberation, and it proved to be a happy one. At a point on F. Wheelock's farm, about 2 miles to the west of the above workings, the three veins spoken of in the first part of the paper, were proved on the surface, and the drill was set up 40 feet to the south of the most southerly of the three (the "Shell Ore" vein). (See Plate V.) The crops of the other two were respectively 84 feet, and 124 feet northerly from the drill. The three veins were intersected at the depths shown, and by reference to the sectional view, it will be seen that they are widening and flattening as they descend. Boring commenced here on Jan. 3, 1901, and finished on April, the drill operating for 1560 hours:

No. 4 Hole.

Dip.	Material Bored Through.	Thickness in Feet.	Total No. of feet from surface.
84°	Surface material	14	14
	Red and blue slates with bands of quartzite (very hard)	98	112
76	Brown hematite ore (showing fossil shells)	38	150
	Slates as above	176½	326½
70°	Brownish hematite ore	38½	365
	Slates and small seams of brown ore	75	440
76°	Brown ore	36	476
	Slates and bands of quartzite	144	620

On the completion of this very satisfactory boring, the drill was moved over on the south side of the valley, formed by the Torbrook or Black River, and boring was commenced well up on the South Mountain ridge. The drill was situated close to a vein of compact magnetite, whose surface measurements gave the writer the following results taken from north to south :

Material.	Feet.	Inches.	Feet.	Inches.
Ore	5	..		
Slate			2	10
Ore	1	..		
Slate			1	1
Ore	1	10		
Total	7	10	3	11

It should be stated that at the time of measurement the width given in the above section shows all the ground then opened, but it is possible that 7 feet 10 inches may not represent the extreme width of ore in the vein.

This and other deposits on the south side of the valley have been traced on the surface for long distances, and analyses of these southern beds show the following results: *

No.	Metallic Iron.	Silica.	Phosphorous.	Sulphur.	Manganese.	Titanic Acid.
1	54.70	11.5	.66	.007	....	1.44
2	42.80	10.39	3.96	.01	.52	....
3	54.84	10.80	1.40	.02	.41	....
4	53.10	14.10	.70	.14	.24	....
5	55.40	20.35	.50	....	.28	....

Thus it appears that their characteristics are practically the same as the beds elsewhere in the district.

No. 5 hole produced a section as follows:

No. 5 Hole.					
Dip.	Hours of Boring.	Material.	Thickness in Feet.	Total Measurement from surface.	Remarks.
Gradually	7	Surface	5	5	Casing
changes	$99\frac{1}{2}$	Dark slate, loose and broken	50	55	put down.
from 87°	17	Slate mixed with iron	7	62	Rock
at surface	53	Ore	30	92	generally
to 83° at	$6\frac{1}{2}$	Slate mixed with iron	4	96	loose and
bottom of	68	Dark slates	27	123	broken.
hole.	19	Slate mixed witn iron	7	130	
	76	Ore	29	159	
	36	Slate mixed with iron	13	172	
	51	Black slates	20	192	

* See Gilpin, Iron Ores Nictaux, Nova Scotian Institute Science—session 1894-95.

From this it is obvious that two veins were passed through, both of which flatten with depth. (See Plate V.)

Plate VI is a plan showing the surface features of the locality.

A few notes collected by the writer relative to the rate and cost of boring with this drill as proved by practical experience may be found interesting:

In boring the 620 feet hole on the Wheelock Farm 1560 hours were employed, which time included that taken up in the drawing of rods, sharpening bits and cutters, and other minor delays, so that fairly deducting say 25% of this, it would leave 620 feet of core produced in 1170 hours of actual drilling, or an average rate of boring was attained of over 6 inches per hour.

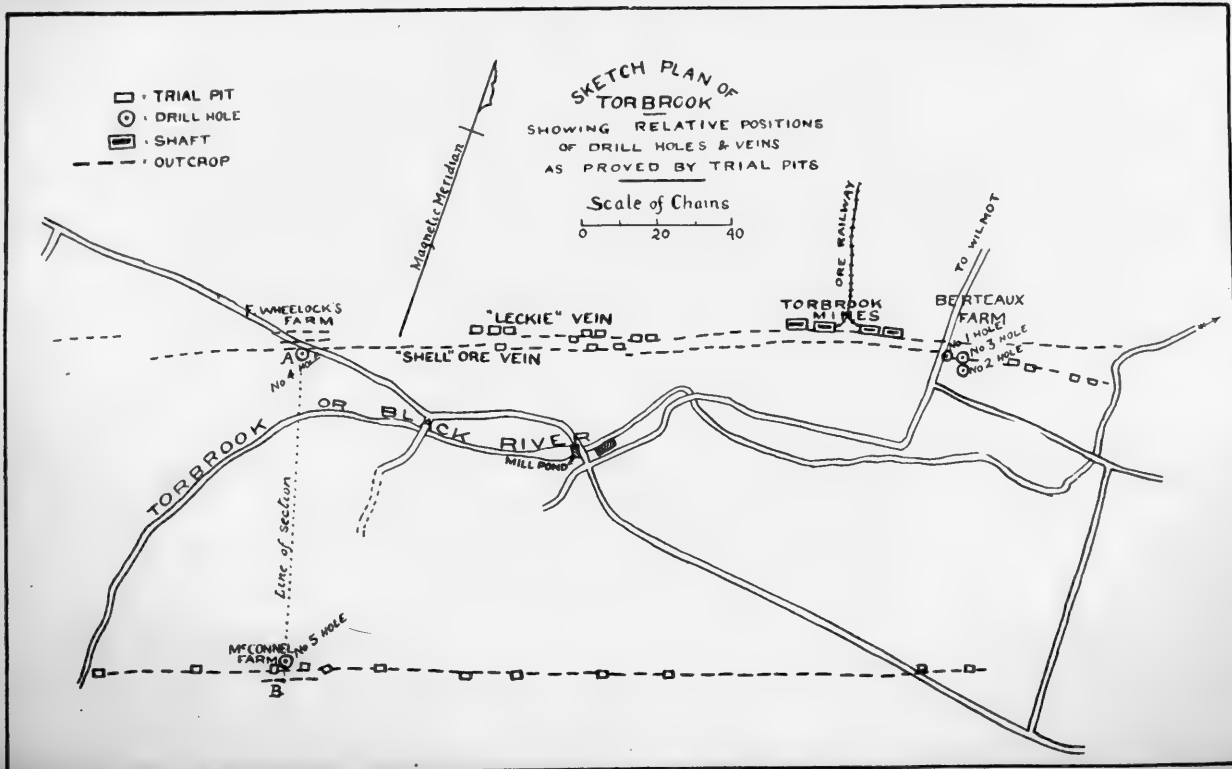
The cost of boring this hole may be very approximately set down at $2.00 per foot, made up as follows:

Labor	$670.00
Management	250.00
Fuel	195.00
Lighting, oil, waste, etc	35.00
Shot	50.00
Wear and tear	50.00
	$1250.00

In considering the above, it must be borne in mind that the rock here though composed of slates and shales, is very hard, and often intercalated with quartzite, and highly ferruginous bands; and further, though the drill runner is a competent man, all the conditions at first were new, and consequently both the cost and rate of boring will probably be materially reduced as the operations progress.

In order to show that this hole was a severe test, the record of no. 2 may be taken in comparison, and it will be seen that on the average over 1 foot per hour was bored. while from 4 feet to 6 feet per hour was done in the softer portions of the rock.

The cost of boring in this softer rock is also reduced by the fact that the cutter is used instead of shot, which latter method is not only expensive in the consumption of shot but also of shot barrel, which costs about $2.25 per foot, and wears away at the rate of about 1 foot of barrel in 50 feet of rock.



(TO ILLUSTRATE PAPER BY MR. WEATHERBE.)

VII.—The Geological History of the Gaspereau Valley, Nova Scotia.—By Professor Ernest Haycock, *Acadia College, Wolfville, N. S.*

(Received for publication 18th Dec., 1901.)

A line drawn across the eastern portion of King's County from the Bay of Fundy to the southeast county line, a distance of about eighteen miles in a southeasterly direction, will cross three distinct bands of country which, with slight local variations, run parallel with the coast and represent the soil and surface of that part of Nova Scotia bordering this bay on the southeast and draining into its waters.

From the shore the surface of the land rises for about four miles in gentle undulating slopes to the crest of the ridge, which marks the boundary of this northernmost band. At short intervals the brooks have cut deep trenches at right angles to the coastline, and these, from their steep sides and generally abrupt character, are locally known as vaults Thus the surface, though sloping but gently seaward, is very uneven and the drainage good. The soil is dark grey, thin and stony, scarcely concealing, in many places, the underlying rock, and largely made up of its more resistant constituents. Where not boggy the land is thus subject to drouth, and adapted to pasturage rather than to tillage.

The underlying rock is an ancient lava-flow, or a mass formed by successive lava-flows, and the peculiar features of the soil and surface are the natural results of the chemical and mechanical action of subaerial forces upon its gently sloping sheets.

From the crest of the ridge the surface drops suddenly away to an undulating plain but little above sea-level, about seven miles wide, made up of alternate strips of level marsh and smoothed and rounded ridges. When one leaves behind the rough roads, lined with the rail fences of stony pasture and hay lands or flanked by steep slopes with their scanty covering

of spruce and fir, and emerges upon the crest of the ridge, this lovely plain lies spread out beneath like a picture. With white June clouds sailing across a blue sky, patches of shadow and sunlight sweeping across the squares and parallelograms of deep brown ploughed-land, pink and white apple-orchards and grass-green marsh to the purple slopes of tidal flats and blue sparkling waters of the basin, this plain presents a picture to the onlooker that is in the strongest contrast to the rough hard lines and sombre coloring of the land and life at his back; for the life necessarily reflects the character of the land whence it draws its sustenance.

Here again, to the underlying rock, hidden by its own debris except where tidal scour has swept away the crumbling fragments from the shore, is due the soil and surface that makes Cornwallis the garden of Nova Scotia. It is red sandstone, in some parts coarse and gravelly but mainly fine-grained, rapidly breaking up with rain and frost and forming a sandy loam particularly adapted to the growth of root-crops and fruit trees.

The southern edge of this plain meets the northern edge of a gentle slope which, within a mile or two, rises to an older loftier plain some five hundred or six hundred feet above the sea. Although carved and sculptured along its borders by water-courses, the uniform elevation of the detached ridges and the main mass, and the regular and even sky-line when viewed from the crest of the North Mountain opposite, point to it as a base-leveled and then elevated and dissected plain, and to the essential unity of the separated ridges and the central portion.

This third band stretches for about seven miles to, and then beyond, the southeast county line. Towards the eastern border of the county it descends somewhat and is abruptly truncated by the Avon River, forming the well-known Horton Bluffs. Its southwestern extension forms the central watershed of the province.

Within this strip the surface is generally level, with low hills, sluggish drainage and abundant lakes in the inner portions, steep slopes, rapid streams and deep water-courses along the borders.

The soil is more variable. Boulder-clay lies in thin sheets or in thick masses in some places on the North Mountain; it is more abundant in the Cornwallis Valley; but it reaches its greatest development along the bordering slopes and in the minor depressions of the elevated southern band. This deposit almost always forms deep and heavy but workable soils. Along the lower slopes it is made up in large part of debris dragged and pushed from the adjacent valley, and to that extent it possesses the fertility of the valley soils; but farther south the slates make up a larger and larger portion and the soils are correspondingly poorer. Where the boulder-clay is wanting, the underlying slates are bare or thinly covered by a worthless soil; while farther south towards the granite country the surface is thickly strewn with granite boulders and wholly given over to forest growth.

The town of Wolfville lies at the foot of the northern slope of this elevated band of country, but the slate ridge to the south of the town, though essentially a part of the plain above described, is cut off from it by a river valley and narrow strip of fertile land which duplicates in every essential character the broader Cornwallis Valley to the north. The Gaspereau Valley is as essentially an outlying fragment of the Cornwallis Valley as the Wolfville ridge is an outlier and separated fragment of the broad southern tableland.

This ridge, some three hundred feet in height behind the town of Wolfville, gradually rises towards the southwest and within a few miles becomes level with and a part of the plain to the southeast. To the northeast it descends with long and convex sweeps, sinking beneath the marsh at Lower Horton. From its southern brow of slate the observer looks down upon a silvery stream winding through double lines of drooping willows, or through level intervales rising into broad low terraces, which sweep with many a curve up into the bounding hills, the whole presenting a scene of quiet and tranquil beauty that the broader valley cannot equal.

Opposite Wolfville the valley bottom is rather more than a mile in width. Eastwardly, as the enclosing northern ridge

becomes less pronounced, drumlin-like hills of boulder-clay increasing in abundance encroach from both sides upon the valley and veneer the eastward extension of the table-land beyond. Westwardly this table-land curves gradually in around the head of the valley which, within a few miles, becomes a deep gorge within steep walls of slate.

These topographic features are in part dependant on the characters of the underlying geological formations; in part they depend on structural features, subsequent to the deposition, and independent of the characteristics, of the rocks.

In the region under discussion these rocks present considerable variety in texture and composition. Passing over the newer and unconsolidated sediments, that form the marine marshes, the terrace gravels, and the hills and sheets of boulder-clay, to the foundation rocks of the district, we find uppermost and resting against the lower slopes of the ridge at Wolfville a dull red sandstone composed of a variable mixture of grains of different minerals. Rounded particles of white and colorless quartz appear to predominate, and minute gleaming flakes of both muscovite and biotite are scattered through the rock. Bright red specks are numerous, and according to their relative abundance the sandstone varies considerably in coloring between red and grey. The cementing matter is calcite, which is present in considerable quantity filling the interstices between the other minerals and effervescing briskly when the rock is touched with acid The size of the grains also varies considerably and rounded pebbles of white vein quartz are not uncommon. The stratification is uneven and the beds dip north at angles of from 10 to 12 degrees.

This sandstone, possessing the same general characters, but varying in texture and in the relative abundance of its constituents, underlies the whole Cornwallis Valley and extends westwardly for upwards of 90 miles. Eastwardly it forms a narrow interrupted band along the margin of the Basin of Minas, which appears to lie in a slight depression of its surface.

Near Wolfville this formation, which is regarded as of

Triassic age, is only found along the base of the hills. Deeply buried by heavy accumulations of boulder-clay it forms the first low rise or step, but is not known to ascend the slopes of the southern tableland. Its contact with the rocks that form these slopes is not visible here, but the inclination of the beds is such that their continuation would carry them up over, and thus indicate that they rest upon, the next appearing beds to the south.*

These older beds, dipping northeasterly at angles of from 12 to 20 degrees, first appear at or near the surface within a few hundred yards of the above mentioned Triassic sandstone. They are dark grey, drab, purplish and black shales, in thin layers, containing abundant plant remains. These shales become more sandy to the south, passing first into fine-grained sandstones which separate in weathering into remarkably uniform thin laminæ. These in turn are underlaid by coarser and coarser grey sandstones, with occasional interstratified beds of black mud-rock and occasional layers of conglomerate, in more and more variable uneven or lenticular strata, as the crest of the ridge and the base of the formation are approached. This whole series is inclined to the northeast at angles varying from 5 to 20 degrees. If the strata were continued, this inclination would carry them up over the slates which are the next appearing rocks to the south.

The contact of the sandstone and slate is concealed by surface material, but the above mentioned geographical and structural relations point to the sandstones as the newer rocks. The occurrence of pebbles and partially worn fragments of slate in the coarse sandstone beds, and the unmetamorphosed condition of the occasional black carbonaceous layers very near the contact with the slate, are convincing proofs of the subsequent deposition of the sandstone and shale series.

This sandstone is largely made up of sub-angular, grey, translucent, quartz grains. Muscovite is common, and the presence of small ironstained cavities points to the former presence

*At Avonport, this unconformable superposition is revealed by a fault which brings up the base of these red beds to the surface of the beach.

of some iron-containing mineral, now decomposed and in part removed. Soft slate-colored specks and pieces, which are doubtless fragments of the slate formation beneath, are also present. The cementing matter of the rock is a light grey powdery substance, probably decomposed feldspar, which appears to be quite easily removed by the mechanical action of rain. There is no effervescence with acids, showing the absence of carbonates.

Because of its constituent minerals the rock is light grey in color, although the joint surfaces are frequently stained a dark red by iron oxide. This is a further indication of removal of iron oxide; and the absence of carbon from these coarse and somewhat porous sandstones when compared with its abundance in the accompanying fine-grained argillaceous beds, is suggestive of the mutual decomposition of the organic substances and iron-containing minerals, and their subsequent removal in solution by the underground water.

The prevalent red color of the overlying Triassic red sandstones, which, without doubt, were derived in large part from these older sandstones, is probably due to the subsequent oxidation and precipitation of these same dissolved iron compounds.

Because of their relations to adjacent formations, and their fossil contents, this series of beds has been regarded as of Lower Carboniferous and even of Devonian age.*

A short distance south of the last outcrop of sandstone, greenish-grey compact slates with clean-cut joint planes come to the surface in many places along the summit of the ridge, and generally underlie the country to the south and west. At this locality the cleavage is nearly vertical and the beds dip northwesterly at angles of from 20 to 70 degrees. Several almost vertical veins of quartz, from one to two feet in thickness, lie in the slate along the southern brow of the ridge approximately parallel with the cleavage planes of the rock.

Just below the southern brow, a narrow band of sandstone, exactly similar to the coarser beds of Carboniferous sandstone above described, crops out at the top of the slope. Its elevation

*See H. M. Ami, Summary Report of the Geol. Surv. Dept. for 1898. Pp. 180-182.

above the Gaspereau Valley is about 200 feet, and, like the similar beds on the northern slope, it dips to the northeast or directly into the hill, and seemingly must pass beneath the slate. That it does not is proved by the presence of fragments of the slate and vein quartz in the sandstone itself, and some other explanation of this relation must be sought.

Along the lower slopes to the south, and in the bottom of the Gaspereau Valley, the underlying rock is concealed by surface material; but along its south side the brooks from the southern tableland have plowed deep furrows at right angles to the valley in the surface material and rock formations beneath, and have revealed the whole structure from the top of the terraces which flank the river to the level of the high land beyond. The first rocks to appear from beneath the terraces in the Angus brook are grey or brown sandy shales in rather thin layers. Their surfaces are abundantly ripple-marked, the ridges of the ripples running generally north 70° west. Worm trails are common; and the surfaces frequently bear the imprints of stems of Lepidodendra. These beds dip to the north at an angle of about 20 degrees, and the brooks flow directly across them at right angles to the strike and in the direction of the dip, so that in stepping from bed to bed as they successively come out from beneath each other, one is passing to older and older strata while ascending the brook and the slope. There is a good deal of local variation in the direction of the strike and in the amount of inclination from the horizontal. An average strike, however, would be a little north of west; an average dip about 15 degrees in a general direction a little east of north.

The beds vary in composition from sandy to argillaceous and carbonaceous shales, and in coloring from grey or brown to black according to the abundance of organic matter and the degree to which they have been open to the passage of underground water. Here, as in the series of strata lying on the north slope of the Wolfville ridge, the finer sediments are succeeded by coarser and coarser materials with occasional interstratified layers of black mud-rock as we pass down into the series and up the slope of the

hill, until we come to massive beds of coarse irregularly bedded sandstone with sub-angular quartz grains powdery cementing matter and all the conspicuous features of the sandstones forming the basal members of the Horton series before described.

In the Duncan Brook the sandstones finally change, rather abruptly, in character, a soft reddish-brown substance appearing and making up a larger and larger portion of the rock, until it passes at a well-defined boundary, into a soft argillaceous rock with bright ribbon-like bands of coloring where the edges of highly inclined green, brown and drab layers have been smoothed and rounded by the stream. This rock is evidently the source of the soft brown constituent of the immediately over-lying sandstones, and furnishes certain proof that they are newer than and laid down upon these argillaceous beds.

Cleavage is not well-marked in these underlying clay rocks at this point, but the bedding is plainly shown by the color banding and by the occurence of occasional gritty layers. The dip at the contact is to the southeast, but in passing up the brook the beds gradually become vertical and then dip to the northwest, suggesting an overturn. The rocks also change gradually to compact bluish slates with well-deffned cleavage.

The succession in the next brook to the east is the same, but the contact of the two formations is concealed by loose material in the bed of the brook. The argillaceous color-banded beds are well exposed, dipping to the southeast at an angle of 45 degrees. Dr. Ami has found *Dictyonema Websteri* in these beds and considers them as of Silurian age.* Farther south, these are succeeded by blue slates, as in the Duncan Brook.

The topographic features of the region have been stated to be due in part to the characteristics of the underlying geological formations, in part to structural phenomena subsequent to the deposition, and independent of the characteristics of these rocks.

Wolfville rests at the junction of the slate with the overlying sandstone. From the town this junction extends eastwardly, ascending the ridge obliquely to the crest, where it suddenly

*Summary Report of the Geol. Surv. of Canada for year 1898. Pp. 180-182

curves to the southwest and just below the brow of the hill continues along in that direction for about half a mile to the westernmost outcrop of the sandstone on the north side of the valley. The next outcrop of sandstone occurs on the opposite side of the Gaspereau Valley, about a mile and a half to the southwest, in a brook just west of Gaspereau Village. It is here about two hundred feet below its last mentioned occurrence on the brow of the ridge, and its contact with the slate lies within a few rods of this exposure, as the next watercourse to the west lies in compact bluish slates. The line of contact next ascends the slope, but curves eastwardly before reaching the edge of the southern tableland and extends in that direction for about three miles, when it again sweeps around southerly, and then southwesterly, up the valley of the Half-way River.

The slate is tough and resistant, and the country occupied by it to the southwest of this bounding line presents smooth level outlines gashed by sudden gorges. The sandstones and shales to the north and east of it are variable in hardness but relatively less resistant than the slates, and the country underlaid by these younger rocks lies, as a rule, at a lower level and presents broadly undulating outlines.

The Cornwallis Valley has a geological history which has already been traced out as far as the records have been available and intelligible to the writer up to the present time.* The Gaspereau outlier has been subject to the same general changes, but its separation from the main portion calls for additional explanation.

If we imagine a vertical plane cutting deep into the earth's crust and extending north and south from the borders of the Minas Basin at Wolfville to the edge of the elevated southern plain, and if the part on the west side were removed so that we could see the underlying structure of the whole district, the surface exposures lead us to believe that the rocks in the geological section thus laid bare are arranged as in the accom-

* "Records of Post-triassic Changes in Kings County, N. S." Transactions of the Nova Scotian Institute of Science, Vol. X., Session 1899-1900. Pp. 287-302.

panying Plate VII, Fig. 1, in which the horizontal and vertical distances are represented on the same scale of two inches to one mile.

The most striking feature of this section is the repetition of geological formations. The red Triassic sandstone of the margin of the Basin is underlaid by the shales and sandstones of the Horton series, which are in turn underlaid at the summit of the ridge by slates. Upon the corresponding slope on the opposite side of the valley, shales and sandstones are again underlaid by slates. The red sandstone is not found in the Gaspereau Valley along the line of the section.

Several interpretations of the underlying structure are suggested by the surface indications. The beds are all water-formed, and all dip to the northern quadrant of the compass, so that the first and simplest explanation is that they form successively deposited series, as shown in Fig. 2, the southernmost slate older than and succeeded unconformably by the southern series of sandstone and shale, this dipping beneath and therefore older than the slates of the Wolfville ridge, and these again unconformably overlaid by the Wolfville sandstone and shale series, and these again by the calcareous red sandstones of the Cornwallis Valley.

A brief study of the rocks, however, reveals the fact that the sandstone and shale formations of both slopes are alike, not only in mineralogical composition but also in fossil contents, and that they are merely geographically separated parts of the same formation. If further reasons for rejecting this explanation were necessary, the slates also possess similar characteristics, and we know of no way in which the clay-slates of the Wolfville ridge could have been cleaved and altered while the sedimentary beds beneath, often as fine in texture, remained unchanged.

A second explanation is that the rocks appearing at the surface are the northern limbs respectively of two anticlines, as shown in Fig. 3, the joining limb being concealed by the thick surface deposits of the lower slopes of the north side and bottom of the Gaspereau Valley.

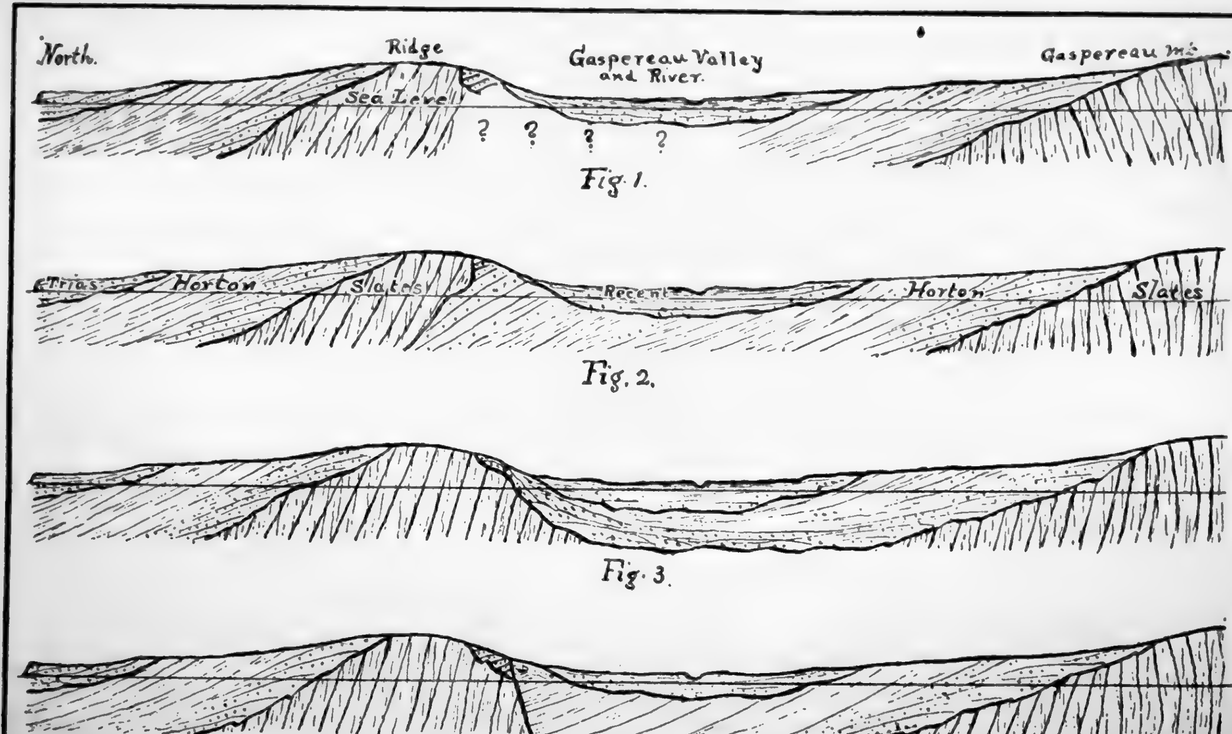


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

SECTION OF GASPEREAU VALLEY, N. S.

An objection to this view is, that the bit of north-dipping sandstone on the southern brow of the Wolfville ridge lies where the south-dipping limb of the northern anticline should be found; and this explanation must also be rejected.

Still a third explanation remains. The repeated outcrop of the same set of beds can be accounted for by a theory that is not in opposition to known facts and even has some special evidence in its favor. If a fault, concealed by the heavy accummulations of surface material, is supposed to extend east and west along the north side of the valley, and the rocks on the north to have moved upwards relatively to those on the south side of the fault, as in Fig. 4, the same strata that dip northerly from the southern side of the valley would be cut off, a mile or more to the north, along with the formation on which they rest. Erosion would act more effectively along the elevated surface, and the soft overlying shales would be quickly removed down to the coarse and more resistant sandstones, and these even worn through to the underlying slates.

On the south side of the fault, the relatively lower position would be less favorable to removal and the softer shales would remain to furnish evidence of the amount of material that had been worn away to lay bare the sandstones and slates of the Wolfville ridge. The northerly dips in the south-sloping surface of this ridge are what we would expect on this theory.

Some additional facts in support of this explanation exist. A line of springs lies along the north side of the valley well up on the slopes of the ridge, and quartz veins a foot or more in thickness, extend along in the same direction, very near the line of springs. If these springs rise in the line of fracture caused by the fault, as appears probable, their occurrence is explicable. The water for these can scarcely be supplied from the almost bare rock surface of the part of the ridge, or escarpment, above, but its source must be rather in the more distant and higher lands to the southwest. A somewhat long underground journey for the water is thus required, and this is favorable to the removal of silica from the rocks along the path and its deposition along

the sides of the fissure as the waters approach the surface, giving rise to the mineral veins that have been mentioned.

If this be the correct explanation, the amount of displacement that has taken place along the fault can be approximately estimated from the average dip, and the present position and elevation of corresponding portions of the same formation. This dip is about 15 degrees, and the horizontal distance between the outcrop of the coarse carboniferous sandstones on the south side of the valley, and the outcrop of the same set of beds on the ridge on the north side, is about two miles; so that a displacement of about 2,500 feet would be necessary to bring the coarse basal sandstones that dip beneath the surface on the south side of the valley to the same elevation on the Wolfville ridge.

The scenic effects of this displacement upon the surface of this portion of the county, are more conspicuous than those described as due to the characteristics of the underlying rocks. By it the harder, more resistant sandstones and compact undering slates are again brought to the surface and produce the Wolfville ridge. By it a long tongue of the Cornwallis Valley, with its fertile farms and apple orchards, has been cut off to form the Gaspereau Valley. If this fault had not occurred, the broader valley would have swept without a break up to the base of the main southern table-land beyond, and the most charming bit of scenery of this portion of Nova Scotia would have no existence.

There are indications that the movement taking place along this line of fracture has been exceedingly slow; that the Gaspereau Valley is even more ancient than the Carboniferous sandstones that rest in it; that it bordered a loftier land to the south which, even in that remote time, supported upon its sheltered slopes and bottom-lands a luxuriant forest of Lepidodendra and magnificent ferns whose remains have been partially preserved in the muddy sediments of an ancient river flowing from this southern land.

Reasons have been advanced for believing that the quartz veins of the slate of the Wolfville ridge have been deposited by

the action of underground water while finding its way to the surface through the fissures of the fractured zone of the Gaspereau fault. These veins, though newer than the slate in which they occur, are still older than the Carboniferous sandstones that overlie them and contain abundant fragments of the white quartz of which they are composed. If the interpretation of their origin be correct, it follows that the fault along which they were formed had its beginnings before the Carboniferous period. The outlining of the Wolfville ridge was contemporaneous with the formation of the fault, and its Pre-Carboniferous origin is thus indicated.

The simplest interpretation of the strip of sandstone dipping into the southern brow of this ridge is that it was deposited along the southern shore when the ridge projected eastwards, as a low point, into the Carboniferous sea. Contemporaneous beds of similar material were deposited on the north side of the point of land. The whole area gradually subsiding, the coarse sandstones that lined the coast in shallow water crept farther and farther up the slopes, covering the low point of slate as the water level rose upon the land. Subsequently, as farther movement along the fault plane took place, these newer beds were broken and their ends pushed upward along its northern side until elevated above the sea and laid bare by ages of erosion, we now see them apparently dipping into the hill of slate along which they were deposited as approximately horizontal beds when the hill itself was a low point of land on the coast of a Carboniferous bay.

The Triassic sandstones have not yet been observed in the Gaspereau Valley along the line of section, although there seems to be no good reason for there not being found if they exist there. A reasonable interpretation of their absence is that when the Triassic sandstones that occur at corresponding levels on the north side of the ridge in the Cornwallis Valley were being laid down as a shallow water formation, along a slowly subsiding coast, the displacement along this fault plane had not taken place to its present extent and the land surface south of the fault was

relatively higher and thus above sea-level. If subsequently submerged and buried by deposits, as seems not unlikely, the beds have been removed along with those that have disappeared from above the present surface of the Triassic beds to the north.

From the above we have reason to believe that displacement along this fault began in Pre-Carboniferous times, continued after the deposition of the Horton series of beds, and had not reached its present proportions when the Triassic rocks of the valley were being laid down. There has probably been no perceptible displacement within recent times, but the slow movement of elevation or subsidence that separated the broken ends of the same beds one half a mile in the lapse of time between the earliest Carboniferous and the Glacial Periods, may still be proceeding at the same rate and the movement since the Glacial Period remain unnoticed.

We can scarcely leave the subject without attempting to decipher some of the faint records of that Palæozoic valley land and bay, the traces of which lie, for the most part, beneath the surface accummulations of more recent geological periods. The slate was then, as now, a surface rock, along the coast at least, as its unconformable contact with the sandstones and the presence of its fragments among their constituents plainly indicate. The region was also subsiding, as the passage of coarse shallow-water sediments up into fine muddy beds, characteristic of deeper, quieter water as plainly proves. The land lay to the south as the derivation of the sediments testifies. As the sea advanced, the coast line must have retreated and its changing outline, for any particular time, is very difficult to fix. It would seem, however, that for the time represented by the basal Wolfville sandstones the coast line must have followed approximately their present line of contact with the slates, outlined earlier in the paper, which was then more nearly horizontal; its present departure from that level being readily explainable by the subsequent displacement along the Gaspereau fault plane.

The early existence of the Wolfville ridge and its undoubted westwardly continuation, would form a barrier then as now to

the direct northward flow of the drainage from that ancient land ; and this little indentation of the coast line was doubtless the estuary of a small river. The absence of coarse conglomerates from the basal sandstones, indicates quiet sheltered waters along the shores. With the exception of ice-transported material, the shore deposits of the Minas Basin average about the same in coarseness as these Lower Carboniferous or Devonian deposits. This would lead to the inference that the ancient Bay was but little more extensive than the Minas Basin of to-day, and that the shores were not exposed to more violent wave action than the more exposed portions of the borders of the present Basin.

This absence of conglomerates also indicates gentle slopes of the land, but we can scarcely do more than speculate as to the character of the interior. The lowest sandstones are evidently made up of the more or less decomposed constituents of a granitic rock. The present boundary of the granite country is to the south, not nearer than from seven to ten miles, and because of the lowering of the surface of the land by erosion in subsequent geological times, this boundary must be nearer now than when these beds were laid down. In what manner all this material could have been transported from the inland areas whence it evidently was derived, is a most perplexing problem.

The land was clothed with a luxuriant vegetation, as the abundant plant remains testify, but the picture of the life that inhabited it must be sketched by the palæontologist. The Geological Record is not one of living forms alone, but geographical and scenic features have a history that forms a too-often overlooked part of that record. This history of the Gaspereau Valley is but a single instance in the evolution of the topographic features of the Nova Scotia of to-day. Whether the facts have been rightly arranged and interpreted, must be left to the judgment of those who follow ; but the great age of this valley, and its checkered history, the latest stages of which have not been looked into, are reminders of the wealth of material about us for study, and of the exceedingly slow and labored process by which the landscape has come to be as it to-day.

VIII.—FOSSILS, POSSIBLY TRIASSIC, IN GLACIATED FRAGMENTS IN THE BOULDER-CLAY OF KINGS COUNTY, N. S.—BY PROFESSOR ERNEST HAYCOCK, *Acadia College, Wolfville, N. S.*

(Received for publication, 18th December, 1901.)

The belt of red Triassic sandstones that extends from St. Mary's Bay to Truro, a distance of one hundred and fifty miles, has not as yet yielded any fossils

It has, for several years, seemed to me unlikely that living things were absent throughout this region when this great series of water-formed beds, often showing ripple-marks and current-bedding, was being laid down. It has seemed equally improbably that at no time or place were the conditions favorable for the preservation of the remains of those living things, if they were present. For these reasons I have believed that such remains exist and are likely to be discovered if carefully searched for.

In many of the finer layers of the red sandstone where it forms bare red cliffs along the north shore of St. Mary's Bay at Rossway, occur spherical greenish-gray blotches with a black central spot, which vary in size from minute specks to spheres an inch in diameter. They appear to be due to the original presence of some organism, the carbon of which has been oxidized from the red oxide of iron which forms the coloring matter of the beds, producing soluble compounds which have been removed, leaving a bleached zone surrounding the former position of the organism.

In beds of the same formation near Pereau, Kings County, the same bleached spheres were noticed in the sandstone, at about the same stratigraphical horizon, taking the surface of contact with the overlying trap as a datum line.

When examining, last summer, the splendid coast section along the southwest side of Minas Basin between Kingsport and

Pereau river, a fragment of a very fine-grained, laminated, reddish-brown, calcareous shale was noticed on the beach which when broken open was found to contain beautifully preserved impressions of small shells that suggested the small bivalve crustacea usually known as ostracods. The origin of the fragments was for some time in doubt. Careful search of the north-dipping beds in the immediate vicinity failed to reveal it, but several other fragments of the same material, some of which contained fossils, were found within a mile or two of the place where the first piece of shale was found.

The surface of the red sandstone is here surmounted by a rather thick coating of boulder-clay. About midway between Kingsport point and Pereau river this sheet descends to near the level of the beach, and is well exposed and accessible to examination where a small brook meets the shore. A brief search in this formation brought to light a glaciated fragment of the same material, which when broken open revealed the same fossils and the problem of the immediate origin was solved.

The location of the strata from which these fragments were detached by the ice of the Glacial Period has not been fixed as yet. The striation of the bed-rock in this county, and the presence of amygdaloidal trap from the North Mountain in the boulder-clay, indicate that the ice moved and brought its load of clay and stones from the northwest. The source of these fragments must also be to the northwest, but in that direction the Triassic red sandstone extends to the trap of the North Mountain. Beyond the trap, on the very shore of the Bay, is a newer formation of greenish calcareous shale; but a careful study of every exposed section of these newer beds has revealed no layers in any respect resembling the fragments in color, composition or fossil contents, and there is no evidence that they were derived from that formation. That they were derived from beds on the Cumberland shore, the more distant New Brunswick coast or the bottom of the Bay of Fundy is also unlikely, so that we must look to the Triassic beds intervening between the Kingsport shore and the North Mountain as the source of the fragments.

Some internal evidences of this derivation are found in the fragments themselves. The material differs from the usual red sandstone beds only in fineness of texture. It contains the minute spherical blotches that have been described as occurring in these sandstones at Rossway and Pereau, and the Pereau locality lies about two miles to the north. Again, the glaciation of the fragments does not indicate a long journey; though deeply scratched, the corners are only partially rounded. The rather soft and brittle nature of the rock is also unfavorable to a long exposure to ice action. Thus there seems to be little doubt that these fossils were derived from the Triassic sandstones; that the layers from which they were derived lie between Kingsport point and the contact of the sandstone and trap on the southern slope of the North Mountain, and that they are more likely to be found on the north side of the Pereau river.

If the origin of the fossils proves to be as supposed, they are, so far as my knowledge goes, the first recorded animal remains from this formation in Nova Scotia; and they may help to fix the age of a series of beds that heretofore have had their position in the Geological Record determined by their lithological resemblances to a formation in the Connecticut Valley several hundred miles distant.

IX.—1 :—PHENOLOGICAL OBSERVATIONS OF THE BOTANICAL CLUB OF CANADA, 1900 ;

2 :—ABSTRACT OF PHENOLOGICAL OBSERVATIONS ON THE FLOWERING OF TEN PLANTS IN NOVA SCOTIA, 1900 ; WITH

3 :—REMARKS ON THEIR PHENOCHRONS—BY A. H. MACKAY, LL. D., *Halifax.*

(Read May 13th, 1901.)

1.

PHENOLOGICAL OBSERVATIONS, CANADA, 1900.

STATIONS AND NAMES OF THE OBSERVERS.

Nova Scotia.

Yarmouth, Yarmouth Co.—Miss Janet Keith Bruce Kelley.
Berwick, Kings Co.—Miss Ida A. Parker.
Musquodoboit Harbour, Halifax Co.—Rev. James Rosborough.
Wallace, Cumberland Co.—Miss E. G. Charman.
East Wallace, Cumberland Co.—Miss A. B. Mackenzie

Prince Edward Island.

Charlottetown—Principal John MacSwain.

Ontario.

Beatrice, Muskoka—Miss Alice Hollingworth

Assiniboia.

Pheasant Forks—Mr. Thomas Donnelly.

Saskatchewan.

Willoughby—Rev. C. W. Bryden, B. A.

British Columbia.

Vancouver—Mr. J. K. Henry, B. A.

PHENOLOGICAL OBSERVATIONS, CANADA, 1900.

Day of the year 1900 corresponding to the last day of each month.

Jan	31	July	212
Feb	59	Aug	243
March	90	Sept	273
April	120	Oct.	304
May	151	Nov	334
June	181	Dec.	365

(First flowering or fruiting of plants and first appearance of migratory animals, etc.)

Number.		Yarmouth, N. S.	Berwick, N. S.	Musquodoboit, Halifax, N. S.	Wallace, N. S.	East Wallace, N. S.	Charlottetown, P. E. I.	Muskoka, O.	Pheasant-Forks, Assa.	Willoughby, Sask.	Vancouver, B. C.
1	Alnus incana, Willd	....	95	110	105	102	137	113	....	....	66
2	Populus tremuloides, Michx	....	....	111	109	....	137	113	111	....	....
3	Epigæa repens, L	102	80	101	119	115	119	124	....	....	....
4	Viola cucullata, Gray	112	115	141	140	136	....	119	126	....	[1] 91
5	V. blanda, Willd	112	128	127	136	134	....	126	132	....	....
6	Acer rubrum, L	....	124	134	124	129	148	120	[d] 125	....	[2] 91
7	Houstonia cærulea, L	....	....	148	....	....	....	....	....	....	....
8	Equisetum arvense, L	118	120	....	150	140	....	143	....	....	77
9	Taraxacum officinale, Weber	30	124	136	138	128	144	126	132	....	....
10	Erythronium Americanum, Ker	...	....	....	....	....	....	116	....	....	....
11	Hepatica triloba, Chaix	....	....	....	....	....	....	126	[a] 98	[a] 112	....
12	Coptis trifolia, Salisb	137	122	132	144	140	....	140	....	...	....
13	Fragaria Virginiana, Mill	126	124	136	137	139	154	140	132	....	....
14	" (fruit ripe)	....	....	....	168	169	....	....	169	....	....
15	Prunus Pennsylvanica, L	....	150	152	156	140	....	140	....	....	[3] 107
16	" (fruit ripe)	....	...	....	210*	....	....	....	205	....	....
17	Vaccinium Penn. v. Can., Lam	....	148	....	150	152	....	140	....	....	[4] 71
18	" (fruit ripe)	....	....	....	210*	....	....	....	....	....	....
19	Ranunculus acris, L	147	151	161	157	157	....	161	....	....	....
20	R. repens, L	147	....	....	176	....	....	....	....	....	....
21	Clintonia borealis, Raf	....	159	155	....	162	....	....	....	....	....
22	Trillium erythrocarpum, Michx	144	144	143	....	....	....	132	....	....	....
23	Trientalis Americana Pursh	....	150	....	160	158	....	152	....	....	....
24	Cypripedium acaule, Ait	....	159	....	....	161	....	170	....	....	....
25	Calla palustris, L	....	...	....	....	155	....	145	....	....	....
26	Amelanchier Canadensis, T. & G.	....	....	148	....	152	....	139	130	...	....
27	" (fruit ripe)	....	....	....	....	....	....	....	191	....	....

*=Year 1899. 1=V. palustris. 2=A. macrophyllum. 3=P. emarginata. 4=V. myrtilloides. *a*=Anemone patens. *d*=Acer Negundo.

PHENOLOGICAL OBSERVATIONS, CANADA, 1900.

Number.	Day of the year 1900, corresponding to the last day of each month. Jan ... 31, Feb ... 59, March ... 90, April ... 120, May ... 151, June ... 181, July ... 212, Aug ... 243, Sept ... 273, Oct ... 304, Nov ... 334, Dec ... 365 (First flowering or fruiting of plants and first appearance of migratory animals, etc.)	Yarmouth, N. S.	Berwick, N. S.	Musquodoboit, Halifax, N. S.	Wallace, N. S.	East Wallace, N. S.	Charlottetown, P. E. I.	Muskoka, O.	Pheasant Forks, Assa.	Willoughby, Sask.	Vancouver, B. C.
28	Rubus strigosus, Michx	...	...	...	...	...	...	...	...	...	...
29	" (fruit ripe)	...	...	...	...	...	...	...	...	...	...
30	Rubus villosus, Ait	...	171	...	...	...	...	...	...	...	...
31	" (fruit ripe)	...	...	...	...	...	...	...	...	...	...
32	Kalmia glauca, Ait	...	...	173	154	...	...	...	...	...	...
33	K. angustifolia, L	186	156	...	179	...	...	...	...	...	...
34	Cornus Canadensis, L.	186	140	162	150	155	...	154	...	...	...
35	" (fruit ripe)	...	...	...	...	...	...	...	...	...	...
36	Sisyrinchium angustifolium	155	171	163	159	163	...	...	...	...	...
37	Linnæa borealis, L	...	...	163	...	165	...	157	...	...	...
38	Linaria Canadensis, Dum.	...	...	...	...	...	...	...	...	...	...
39	Rhinanthus Crista-galli, L	...	...	174	...	182	...	...	...	...	...
40	Sarracenia purpurea, L	...	...	...	...	...	...	172	...	...	...
41	Brunella vulgaris, L	...	...	...	...	176	...	175	...	...	...
42	Epilobium angustifolium, L.	...	...	202	201	...	...	190	...	...	...
43	Rosa lucida, Ehrh.	186 *	181	...	...	...	...	...	147	...	5 134
44	Hypericum perforatum, L.	226	186	...	...	...	...	182	...	...	...
45	Leontodon autumnale, L	186	...	184	...	...	...	...	...	...	...
46	Prunus Cerasus (cultiv.)	...	147	...	150	154	157	...	...	...	96
47	" (fruit ripe)	...	...	...	196	...	...	...	...	...	160
48	Cratægus Oxyacantha, L	...	...	...	...	...	163	...	...	...	...
49	C. coccinea, L	...	...	...	...	...	...	149	142	...	...
50	Prunus domestica (cultivated)	146	...	...	148	165	...	141	...	...	87
51	Pyrus malus (cultivated) early	123	151	159	150	151	158	142	...	...	100
52	" " late	...	...	...	158	152	...	...	...	...	...
53	Ribes rubrum (cultivated)	...	145	...	145	141	...	143	132	...	
54	" (fruit ripe)	...	...	...	193	...	...	182	...	...	...

*=Year 1899. 5=R. Nutkana.

PHENOLOGICAL OBSERVATIONS, CANADA, 1900.

Number.	Day of the year 1900 corresponding to the last day of each month. Jan. .... 31 July ....212 Feb .... 59 Aug ....243 March......... 90 Sept ....273 April..........120 Oct. ....304 May...........151 Nov...........334 June ....181 Dec...........365 (First flowering or fruiting of plants and first appearance of migratory animals, etc.)	Yarmouth, N. S.	Berwick, N. S.	Musquodoboit, Halifax, N. S.	Wallace, N. S.	East Wallace, N. S.	Charlottetown, P. E. I.	Muskoka, O.	Pheasant Forks, Assa.	Willoughby, Sask.	Vancouver, B. C.
55	R. nigrum (cultivated)	....	....	....	155*	144	....	143	....	....	....
56	" (fruit ripe)............	....	....	....	197	....	....	190	....	....	....
57	Syringa vulgaris, L. (cultiv.).........	....	157	....	159	163	163	148	148	...	....
58	Solanum tuberosum, L..............	....	....	....	....	....	....	179	203	....	....
59	Phleum pratense, L....	....	....	202	167	....	....	188	...	....	....
60	Trifolium repens, L...............	....	...	....	167	168	....	....	...	...	....
61	T. pratense, L	...	*156*	....	165	168	....	161	....	....	135
62	Triticum vulgare, L..................	159	...	....	....	....	....	....	....	....	....
63	Avena sativa, L.	159	....	....	....	....	....	....	....	....	....
64	Fagopyrum esculentum, L	235	....	....	....	....	....	....	....	....	....
65a	Earliest full leafing of tree..........		....	....	131	....	....	147	....	....	....
65b	Latest " "	....	....	....	163	....	....	158	....	....	....
66	Ploughing (first of season)............	....	115	....	113	....	125	121	95	109	....
67	Sowing " "	....	122	....	142	....	....	127	103	111	....
68	Potato-planting "	....	....	....	141	....	....	130	121	121	....
69	Sheep-shearing "	....	138	....	143	....	....	136	....	....	....
70	Hay-cutting "	....	....	....	....	....	....	194	209	....	....
71	Grain-cutting "	....	....	....	....	237*	238	221	221	....	....
72	Potato-digging "	....	....	....	268*	....	....	267	....	....	....
73a	Opening of rivers "	....	....	....	80	....	96	...	91	....	....
73b	Opening of lakes "	....	....	....	....	....	....	....	....	....	....
74a	Last snow to whiten ground.........	....	102	...	116	....	....	104	123	....	....
74b	" to fly in air	....	147	....	132	....	134	123	....	....	....
75a	Last spring frost—hard...............	....	....	....	139	155	....	130	....	....	....
75b	" " hoar	....	....	....	168	....	....	139	....	....	....
76a	Water in streams—high..............	....	....	....	....	111	....	....	....	....	....
76b	" " low..............	....	....	....	....	....	....	....	....	....	....

*=Year 1899.

PHENOLOGICAL OBSERVATIONS, CANADA, 1900.

Day of the year 1900 corresponding to the last day of each month.

Jan	31	July	212
Feb	59	Aug	243
March	90	Sept	273
April	120	Oct	304
May	151	Nov	334
June	181	Dec	365

(First flowering or fruiting of plants and first appearance of migratory animals, etc.)

Number.		Yarmouth, N. S.	Berwick, N. S.	Musquodoboit, N. S.	Wallace, N. S.	East Wallace, N. S.	Charlottetown, P. E. I.	Muskoka, O.	Pheasant Forks, Assa.	Willoughby, Sask.	Vancouver, B. C.
77a	First autumn frost, hoar	*259	....	....	*246	....	251	....	....	239	....
77b	" " hard	*293	....	....	*279	....	....	313	....	258	....
78a	First snow to fly in air	*290	....	....	*277	....	....	....	....	275	....
78b	" whiten ground	....	....	....	....	....	....	316	....	306	....
79a	Closing of lakes	....	....	....	*319	....	....	....	....	....	....
79b	" rivers	....	....	....	*362	....	345	....	....	....	....
80	Thunderstorms—dates	111	....	....	99	....	109	108	112	115	....
		....	....	....	....	....	....	...	113	....	....
		....	....	....	....	....	....	133	114	....	....
		138	..	....	....	....	136	134	126	122	....
		....	....	....	....	....	....	....	132	...	....
		....	151	....	158	....	....	158	134	....	....
		153	....	....	172	....	172	....	147	147	....
		....	....	....	....	....	....	177	....	....	....
		....	....	....	179	179	....	....	153	153	....
		....	....	....	180	180	....	....	....	156	....
		*197	....	....	181	....	181	....	....	165	....
		*198	....	...	182	....	....	....	....	...	....
		....	....	....	....	....	189	....	....	....	....
		*199	....	....	*194	....	193	192	....	....	....
		....	....	....	*202	....	194	196	...	200	....
		....	....	....	....	....	206	205	208	....	....
		*213	....	....	*207	....	209	210	209	....	....
		....	...	....	*210	....	213	219	211	218	....
		*238	....	....	*218	....	214	226	223	....	....
		....	....	...	*225	...	215	....	224	....	....
		....	....	...	*239	....	236	237	....	229	....

* = Year 1899.

PHENOLOGICAL OBSERVATIONS, CANADA, 1900.

Day of the year 1900 corresponding to the last day of each month.

Jan	31	July	212
Feb	59	Aug	243
March	90	Sept	273
April	120	Oct	304
May	151	Nov	334
June	181	Dec	365

Number.	(First flowering or fruiting of plants and first appearance of migratory animals, etc.)	Yarmouth, N. S.	Berwick, N. S.	Musquodobit, N. S.	Wallace, N. S.	East Wallace, N. S.	Charlottetown, P. E. I.	Muskoka, O.	Pheasant Forks, Assa.	Willoughby, Sask.	Vancouver, B. C.
80	Thunderstorms—dates	260	....	....	....	...	238	....	....	233	....
		*261	...	...	*246	....	....	259	...	....	....
		....	....	...	..	....	265	262	....	....	....
		...	..	...	*273	....	....	280	....	....	....
		....	....	....	....	....	....	299	....	....	....
		....	....	...	....	....	....	326	....	...	....
81a	Wild ducks migrating, N	....	93	...	....	....	...	....	100	....	....
81b	" " " S	....	....	....	....	....	....	...	....	....	....
82a	" geese " N	...	94	...	78	....	79	110	84	....	....
82b	" " " S	....	....	....	....	....	251	285	....	....	....
83	Melospiza fasciata, North	....	82	...	....	....	104	110	....	....	....
84	Turdus migratorius "	47	67	....	74	....	104	92	*k* 98	*k* 112	....
85	Junco hiemalis "	..	74	....	95	....	111	....	94	....	....
86	Actitis macularia "	....	....	....	....	....	....	....	....	....	....
87	Sturnella magna "	....	....	....	13	....	....	....	....	....	....
88	Ceryle Alcyon "	....	....	....	....	....	....	....	....	....	....
89	Dendrœca coronata "	....	....	....	....	....	....	....	....	....	....
90	D. æstiva "	....	....	....	....	....	....	....	....	....	....
91	Zonothrichia alba "	....	....	....	....	....	....	...	....	....	....
92	Trochilus colubris "	...	138	....	144	....	....	141	....	....	....
93	Tyrannus Carolinensis "	....	143	....	139	....	....	....	....	....	....
94	Dolychonyx oryzivorus "	...	116	....	....	...	....	140	...	....	....
95	Spinis tristis "	....	....	....	....	....	...	....	....	....	....
96	Setophaga ruticilla "	....	....	....	....	....	...	....	....	....	....
97	Ampelis cedrorum "	....	....	....	....	....	....	....	....	....	....
98	Chordeiles Viginianus "	....	144	....	....	...	156	137	....	....	....
99	First piping of frogs	....	94	....	106	...	111	108	97	105	61
100	First appearance, snakes	....	111	....	134	.. .	....	110	103	119	....

*=Year 1899. *k*=M. propinqua.

2.

PHENOLOGICAL OBSERVATIONS, NOVA SCOTIA.

THE TIME OF FLOWERING OF TEN PLANTS, SPRING OF 1900, THROUGHOUT THE PROVINCE OF NOVA SCOTIA.

(Compiled from Phenological Observations made in the Public Schools of the Province.)

The counties are arranged in the order of latitude and longitude, beginning with the South and West. For the ease of comparison the same order will hereafter be followed.

The tables contain merely the phenochrons or average dates of appearance at ten stations on the "coast," "lowlands" or "highlands," as the case may be—the names of the plants being omitted for the purpose of condensation. But the ten plants in order are the following throughout the whole table:

1. Mayflower (Epigæa repens).
2. Blue Violet (Viola cucullata).
3. Red Maple (Acer rubrum).
4. Dandelion (Taraxacum officinale).
5. Strawberry (Fragaria Virginiana).
6. Wild Red Cherry (Prunus Pennsylvanica).
7. Blueberry (Vaccinium Can. and Penn.)
8. Buttercup (Ranunculus acris).
9. Apple—cultivated (Pyrus malus).
10. Lilac (Syringa vulgaris).

The phenochrons of "first" flowering, and flowering "becoming common" of these ten plants on *coast, low inlands and high inlands,* and their general averages, are all lined across the page for the ease of comparison of the effects of coast waters and altitude. The classification of the observation stations into these three groups was made by the Inspectors through whom the schedules were sent to the Education Office.

As a rule, *ten* of the best schedules are averaged in each column. When *ten* good schedules for each of the three divisions of each county could not be had, the *ten* best schedules for the county are averaged, etc.

Phenological Observations.

YARMOUTH COUNTY, 1900.

First Seen.				Becoming Common.				General Phenochrons	
Coast.	Low Inlands.	H gh-lands.	Aver-age.	Coast.	Low Inlands.	High-lands.	Aver age.	Annual date.	Mensual date.
.....	....	.....	88.9	......	....	......	104.6	96.75	7 April.
......	....	......	123.4	......	....	.....	132.8	128.10	9 May.
......	....	......	122.2	......	....	......	131.9	127.05	8 May.
......	....	......	119.5	......	....	.....	133.2	126.35	7 May.
......	....	......	119.5	......	....	.....	134.2	126.85	7 May.
......	....	......	145.7	......	....	......	147.7	146.70	27 May.
......	....	......	135.6	......	....	.....	153.1	144.35	25 May.
......	....	......	143.7	......	....	......	150.8	147.25	28 May.
......	....	......	141.6	......	....	.....	155.8	148.70	29 May.
.....	....	.....	158.6	......	....	.....	167.0	162.80	12 June.
......	....	.....	129.87	.....	....	...	141.11	135.49	16 May.

SHELBURNE COUNTY, 1900.

Coast.	Low Inlands.	High-lands.	Average.	Coast.	Low Inlands.	High-lands.	Average.	Annual date.	Mensual date.
......	....	......	96.4	......	....	......	106.3	101.35	12 April.
......	....	......	125.6	......	....	......	132.9	129.25	10 May.
......	....	......	128.1	......	....	......	134.1	131.10	12 May.
......	....	.....	121.3	......	....	......	129.8	125.55	6 May.
......	....	......	125.8	......	....	.....	132.5	129.15	10 May.
......	....	......	143.0	......	....	......	148.9	145.95	26 May.
......	....	......	134.7	......	....	.....	145.3	140.00	20 May.
......	....	......	143.6	......	....	......	150.3	146.95	27 May.
......	....	......	144.7	......	....	......	153.1	148.90	29 May.
......	....	....	157.9	......	....	......	162.9	160.40	10 June.
......	....	......	132.11	......	....	......	139.61	135.86	17 May.

DIGBY COUNTY, 1900.

Coast.	Low Inlands.	High-lands.	Average.	Coast.	Low Inlands.	High-lands.	Average.	Annual date.	Mensual date.
105.3	100.4	106.7	104.1	111.2	109.0	113.8	111.3	107.70	18 April.
123.2	126.1	122.3	123.9	133.3	133.3	131.5	132.7	128.30	9 May.
135.0	124.3	129.0	129.4	140.4	132.3	134.9	135.9	132.65	13 May.
121.6	123.3	126.1	123.7	138.8	134.6	139.6	137.7	130.70	11 May.
119.6	124.5	124.3	122.3	134.9	135.9	135.1	135.3	129.05	10 May.
145.4	145.9	146.1	145.8	150.0	150.8	152.9	151.2	148.50	29 May.
145.4	143.4	145.1	144.6	152.2	151.3	147.9	150.5	147.55	28 May.
148.7	150.1	147.0	148.6	154.9	155.9	152.6	154.5	151.55	1 June.
147.9	150.3	147.8	148.7	153.8	154.4	156.3	154.8	151.75	1 June.
157.5	160.0	156.6	158.0	164.6	165.0	161.9	163.8	160.90	10 June.
134.96	134.83	135.10	134.96	143.41	142.25	142.65	142.77	138.87	19 May.

PHENOLOGICAL OBSERVATIONS—*Continued.*

QUEENS COUNTY, 1900.

First Seen.				Becoming Common.				General Phenochrons.	
Coast	Low Inlands.	High-lands.	Aver-age.	Coast.	Low Inlands.	High-lands.	Aver-age.	Annual date.	Mensual date.
102.1	97.1	99.4	99.5	112.9	110.8	111.0	111.6	105.55	16 April.
128.1	131.6	129.4	129.7	138.8	133.5	136.8	136.4	133.05	14 May.
127.9	120.8	125.1	124.6	136.1	129.0	130.2	131.8	128.20	9 May.
123.1	123.8	134.8	127.2	134.3	131.8	142.0	136.0	131.60	12 May.
128.9	132.0	132.7	131.2	141.9	145.1	142.6	143.2	137.20	18 May.
142.0	142.8	147.4	144.1	152.7	149.8	151.7	151.4	147.75	28 May.
139.2	145.5	143.2	142.6	149.2	151.5	152.4	151.0	146.80	27 May.
150.6	150.0	153.5	151.4	156.8	156.3	156.2	156.4	153.90	3 June.
148.6	147.3	148.1	148.0	156.9	154.1	155.4	155.5	151.75	1 June.
161.6	156.1	154.8	157.5	168.4	160.6	160.3	163.1	160.30	10 June.
135.21	134.70	136.84	135.58	144.80	142.25	143.86	143.64	139.61	20 May.

ANNAPOLIS COUNTY, 1900.

.....	104.0	107.1	105.6	......	115.9	114.5	115.2	110.40	21 April.
.....	128.6	132.9	130.7	......	135.9	137.9	136.9	133.80	14 May.
......	124.9	127.6	126.3	....	128.0	133.5	130.8	128.55	9 May.
.....	129.6	133.8	131.7	.....	139.6	140.9	140.2	135.95	16 May.
......	128.5	133.2	130.8	......	141.3	139.5	140.4	135.60	16 May.
......	145.6	144.7	145.2	......	151.0	148.5	149.8	147.50	28 May.
......	139.6	144.5	142.0	......	156.6	148.3	152.4	147.20	28 May.
......	150.9	150.6	150.8	......	156.0	156.4	156.2	153.50	3 June.
......	150.3	150.8	150.5	......	156.0	154.2	155.1	152.80	2 June.
......	156.5	158.7	157.6	......	162.0	162.2	162.1	159.85	9 June.
......	135.85	138.39	137.12	......	144.23	143.59	143.91	140.52	21 M

LUNENBURG COUNTY, 1900.

102.6	100.6	101.2	101.5	111.7	115.7	111.2	112.9	107.20	18 April.
131.7	128.3	131.8	130.6	138.2	138.3	136.5	137.7	134.15	15 May.
127.1	128.1	123.5	126.2	131.5	127.8	129.3	129.5	127.85	8 May.
127.4	129.5	133.2	130.0	135.2	136.2	139.2	136.9	133.45	14 May.
130.1	129.9	131.9	130.6	139.3	137.3	141.1	139.2	134.95	15 May.
144.7	141.8	144.4	143.6	150.6	147.7	148.0	148.8	146.20	27 May.
141.8	144.6	144.6	143.7	146.4	153.5	151.4	150.4	147.05	28 May.
151.7	147.8	153.0	150.8	158.3	157.0	157.8	157.7	154.25	4 June.
150.4	149.0	150.2	149.9	156.3	156.0	154.9	155.7	152.80	2 June.
160.4	157.7	157.3	158.5	165.5	164.0	162.4	164.0	161.25	11 June.
136.79	135.72	137.11	136.54	143.30	143.35	143.18	143.28	139.91	20 May.

PHENOLOGICAL OBSERVATIONS—*Continued.*

KINGS COUNTY, 1900.

Firs Seen.				Becoming Common.				General Phenochrons.	
Coast.	Low-lands.	High-lands.	Aver-age.	Coast.	Low-lands.	High-lands.	Aver-age.	Annual date.	Mensual date.
......	103.0	110.2	106.6	.....	111.8	119.2	115.5	111.05	22 April.
......	124.0	182.6	128.3	.....	139.2	141.8	140.5	134.40	15 May.
......	123.1	135.1	129.1	......	129.6	140.2	134.9	132.00	12 May.
......	131.4	138.5	135.0	.....	138.9	143.9	141.4	138.20	19 May.
.....	121.9	133.2	127.5	.....	139.6	143.9	141.8	134.65	15 May.
.....	147.0	148.1	147.6	....	152.6	153.4	153.0	150.30	31 May.
......	148.8	151.8	150.3	......	155.8	155.3	155.5	152.90	2 June.
......	148.8	154.6	151.7	......	157.5	159.9	158.7	155.20	5 June.
.....	147.5	153.5	150.5	......	153.5	157.3	155.4	152.95	2 June.
....	158.0	161.2	159.6	....	162.3	164.8	163.6	161.60	11 June
......	135.35	141.88	138.62	.....	144.08	147.97	146.03	142.32	23 May.

HANTS COUNTY, 1900.

......	99.3	107.0	103.2	......	113.3	116.7	115.0	109.10	20 April.
.....	130.3	129.1	129.7	......	136.6	137.0	136.8	133.25	14 May.
......	125.7	124.0	124.8	......	134.3	130.4	132.4	128.60	9 May.
......	132.1	136.7	134.4	......	138.5	143.7	141.1	137.75	18 May.
......	134.3	133.7	134.0	......	142.3	142.6	142.4	138.20	19 May.
......	149.9	149.9	149.9	......	155.2	152.4	153 8	151.85	1 June.
.....	150.1	152 0	151.1	...	156.4	155.6	156.0	153.55	3 June.
......	152.3	154.0	153.1	......	156.4	158.6	157.5	155.30	5 June.
......	151.8	152.7	152.3	......	157.1	155.6	156.4	154.35	4 June.
......	159.2	161.4	160.3	.....	162.4	166.0	164.2	162.25	12 June.
.....	138.50	140.05	139.28	......	145.25	145.86	145.56	142.42	25 May.

HALIFAX COUNTY, 1900.

103.9	104.3	105.2	104.5	118.1	117.0	120.0	118.4	111.45	22 April.
133.9	126.7	134.0	131.5	141.8	136.5	145.2	141.2	136.35	17 May.
132.2	124.0	127.8	128.0	141.6	131.0	136.0	136.2	132.10	13 May.
130.1	134.4	135.3	133.3	143.0	140.8	142.0	141.9	137.60	18 May.
132.0	128.6	132.7	131.1	144.0	141.4	145.6	143.7	137.40	18 May.
154.1	150.9	146.6	150.5	158.4	152.3	151.5	154.1	152.30	2 June.
143.7	147.3	145.9	145.6	153.3	153.0	153.2	153.1	149.35	30 May.
156.4	153.9	152.7	154.3	162.6	160.0	162.0	161.5	157.90	7 June.
155.2	153.4	152.0	153.5	160.8	158.5	160.8	160.0	156.75	6 June.
162.1	162.6	156.7	160.5	169.0	166.5	163.1	166.2	163.35	13 June.
140.36	138.61	138.89	139.28	149.26	145.70	147.94	147.63	143.45	24 May.

PHENOLOGICAL OBSERVATIONS—*Continued.*

GUYSBORO COUNTY, 1900.

First Seen.				Becoming Common.				General Phenochrons.	
Coast.	Low-lands.	High-lands.	Aver-age.	Coast	Low-lands.	High-lands.	Aver-age.	Annual date.	Mensua date.
......	....	.....	109.1	.....	....	....	120.5	114.80	25 April.
......	....	......	134.1	.....	....	......	142.1	138.10	19 May.
......	....	......	135.6	.....	....	......	139.0	137.30	18 May.
......	....	.....	137.1	.....	....	.....	145.1	141.10	21 May.
.....	....	......	139.7	.....	....	..	149.7	144.70	25 May.
......	....	......	153.8	.....	....	....	159.0	156.40	6 June.
......	....	......	155.9	..	....	.....	162.0	158.95	8 June.
.....	....	....	157.1	.....	....	......	164.2	160.65	10 June.
......	....	......	160.1	.....	....	....	165.9	163.00	12 June.
......	....	.....	167.9	.....	....	......	173.7	170.80	20 June.
......	....	.....	145.04	.....	....	......	152.12	148.58	29 May.

CUMBERLAND COUNTY, 1900.

116.6	110.9	119.0	115.5	122.2	121.1	129.5	124.3	119.90	30 April.
134.7	131.4	137.3	134.5	142.2	138.3	146.7	142.4	138.45	19 May.
132.7	127.3	130.6	130.2	138.9	135.0	135.2	136.4	133.30	14 May.
138.7	140.0	142.2	140.3	144.9	144.6	150.1	146.5	143.40	24 May.
137.0	133.9	138.0	136.3	142.8	141.7	148.6	144.4	140.35	21 May.
148.3	147.5	148.4	148.1	154.1	152.3	154.7	153.7	150.90	5 June.
150.9	146.9	148.0	148.6	154.4	153.8	155.9	154.7	151.65	1 June.
156.5	152.2	158.1	155.6	162.2	159.5	162.9	161.5	158.55	8 June.
154.0	153.0	154.8	153.9	160.4	157.6	159.9	159.3	156.60	6 June.
160.9	160.6	160.9	160.8	166.1	164.3	166.3	165.6	163.20	13 June.
143.03	140.37	143.73	142.38	148.82	146.82	150.98	148.88	145.63	26 May.

COLCHESTER COUNTY, 1900.

111.0	106.5	115.3	110.9	120.5	114.5	121.8	118.9	114.90	25 April.
131.5	127.0	132.9	130.5	138.3	138.0	139.2	138.5	134.50	15 May.
127.9	124.2	126.5	126.2	133.5	133.2	136.3	134.3	130.25	11 May.
133.4	130.9	137.6	134.0	141.3	138.0	143.1	140.8	137.40	18 May.
130.1	133.4	136.8	133.4	140.2	141.1	147.0	142.8	138.10	19 May.
146.7	146.7	147.7	147.0	152.7	151.3	154.1	152.7	149.85	30 May.
151.7	148.7	153.8	151.4	156.3	155.3	159.7	157.1	154.25	4 June.
153.1	155.4	156.4	155.0	158.4	161.6	161.5	160.5	157.75	7 June.
154.7	154.8	156.2	155.2	159.3	159.0	159.6	159.3	157.25	7 June.
164.0	162.3	163.9	163.4	168.4	166.4	168.2	167.7	165.55	15 June.
140.41	138.99	142.71	140.70	146.89	145.84	149.05	147.26	143.98	24 May.

PHENOLOGICAL OBSERVATIONS—*Continued.*

PICTOU COUNTY, 1900.

First Seen.				Becoming Common.				General Phenochrons.	
Coast.	Low lands.	High-lands.	Aver-age.	Coast.	Low-lands.	High-lands.	Aver-age.	Annual date.	Mensual date.
112.1	112.5	121.2	115.3	122.3	122.7	129.1	124.7	120.00	30 April.
132.9	133.4	133.1	133.1	137.8	142.6	139.9	140.1	136.60	17 May.
135.7	122.7	126.9	128.4	138.0	128.7	131.0	132.6	130.50	11 May.
141.7	135.6	139.4	138.9	146.9	141.5	144.4	144.2	141.55	22 May.
138.7	135.4	138.7	137.6	147.1	147.1	145.5	146.7	142.15	23 May.
146.5	151.7	149.7	149.3	153.7	160.1	154.3	156.0	152.65	2 June.
151.6	151.1	153.0	151.9	159.4	160.2	158.2	159.2	155.55	5 June.
154.3	152.8	155.8	154.3	160.4	159.9	161.7	160.7	157.50	7 June.
153.9	156.5	155.5	155.3	158.3	159.3	160.0	159.2	157.25	7 June.
160.8	162.2	161.5	161.5	165.7	166.9	165.7	166.1	163.80	13 June.
142.82	141.39	143.48	142.56	148.96	148.90	148.98	148.95	145.75	26 May.

ANTIGONISH COUNTY, 1900.

......	....	......	118.1	......	....	......	124.9	121.50	2 May.
......	....	......	135.5	......	....	......	141.1	138.30	19 May.
......	....	......	131.8	......	....	......	140.7	136.25	17 May.
......	....	......	136.1	......	....	......	143.6	139.85	20 May.
......	....	......	136.1	......	....	......	149.0	142.55	23 May.
......	....	......	149.8	......	....	......	156.8	153.30	3 June
......	....	......	155.9	......	....	......	162.9	159.40	9 June.
......	....	......	157.7	......	....	......	163.2	160 45	10 June.
......	....	......	157.1	......	....	......	162.2	159.65	9 June.
......	....	......	161.2	......	....	......	167.0	164.10	14 June.
......	....	......	143.93	......	....	......	151.14	147.53	28 May.

RICHMOND COUNTY, 1900.

......	....	......	119.1	......	....	......	128.9	124.00	4 May.
......	....	......	139.4	......	....	......	147.6	143.50	24 May.
......	....	......	138.5	......	....	......	145.6	142.05	23 May.
......	....	......	144.2	......	....	......	152.4	148.30	29 May.
......	....	......	142.2	......	....	......	153.9	148.05	29 May.
......	....	......	159.7	......	....	......	165.1	162.40	12 June.
......	....	......	163.6	......	....	......	170.3	166.95	16 June.
......	....	......	163.0	......	....	......	168.5	165.75	15 June.
......	....	......	168.5	......	....	......	175.0	171.75	21 June.
......	....	......	178.3	......	....	......	183.9	181.10	1 July.
......	....	......	151.65	......	....	......	159.12	155.38	5 June.

PHENOLOGICAL OBSERVATIONS—*Continued.*

CAPE BRETON COUNTY, 1900.

First Seen.				Becoming Common.				General Phenochrons.	
Coast.	Low-lands.	High-lands.	Aver-age.	Coast.	Low-lands	High-lands.	Aver-age.	Annual date.	Mensual date.
......	....	......	110.1	......	....	......	116.2	113.15	24 April.
......	....	......	135.7	......	....	......	140.0	137.85	18 May.
......	....	......	136.2	......	....	......	139.4	137.80	18 May.
......	....	......	135.6	......	....	......	140.0	137.80	18 May.
......	....	......	135.7	......	....	......	141.0	138.35	19 May.
......	....	......	151.3	......	....	......	156.3	153.80	3 June.
......	....	......	158.3	......	....	......	162.7	160.50	10 June.
......	....	......	158.3	......	....	......	164.8	161.55	11 June.
......	....	......	162.3	......	....	......	166.1	164.20	14 June.
......	....	......	168.3	......	....	......	172.2	170.25	20 June.
......	....	......	145.18	......	....	......	149.87	147.52	28 May.

INVERNESS COUNTY 1900.

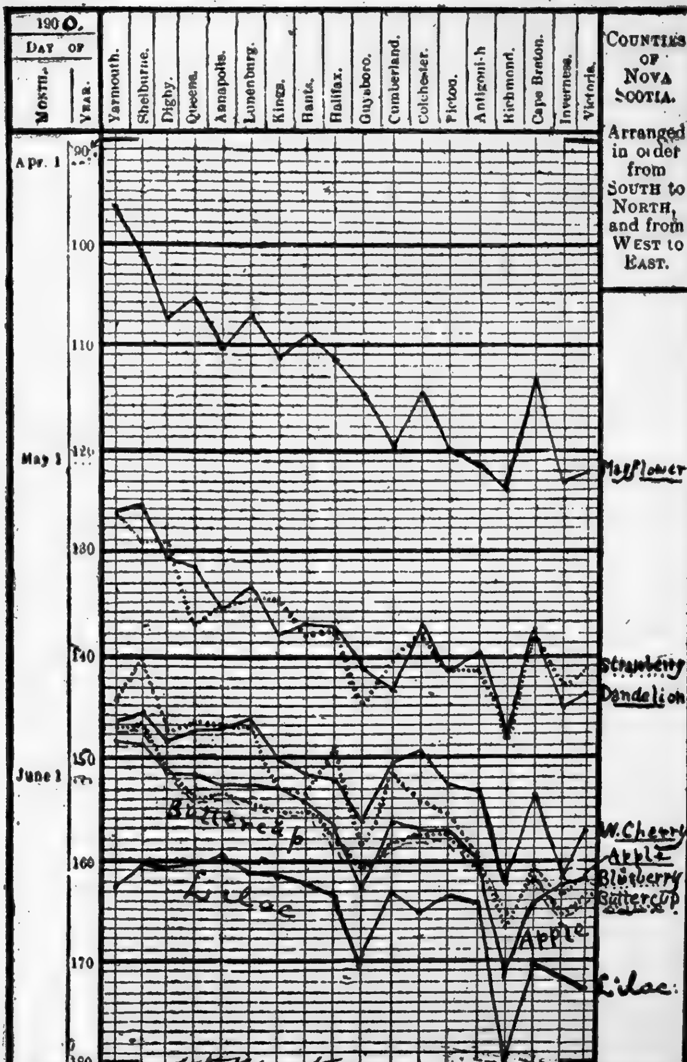
......	....	......	117.8	......	....	......	128.4	123.10	4 May.
......	....	......	134.7	......	....	......	142.1	138.40	19 May.
......	....	......	145.0	......	....	......	153.2	149.10	30 May.
......	....	......	141.6	......	....	......	148.7	145.15	26 May.
......	....	......	137.4	......	....	......	148.4	142.90	23 May.
......	....	......	158.9	......	....	......	164.6	161.75	11 June.
......	....	......	159.6	......	....	......	167.1	163.35	13 June.
......	....	......	163.0	......	....	......	168.1	165.55	15 Juno.
......	....	......	159.7	......	....	......	165.3	162.50	12 June.
....	....	......	162.8	......	....	......	170.3	166.55	16 June.
......	....	......	148.05	......	....	......	155.62	151.83	1 June.

VICTORIA COUNTY, 1900.

......	....	......	119.5	......	....	......	125.1	122.30	3 May.
......	....	......	137.0	......	....	......	142.1	139.55	20 May.
......	....	......	139.3	......	....	......	144.4	141.85	22 May.
......	....	......	140.9	......	....	......	146.9	143.90	24 May.
......	....	......	136.1	......	....	......	146.5	141.30	22 May.
......	....	......	154.4	......	....	......	159.9	157.15	7 June.
......	....	......	158.9	......	....	......	164.6	161.75	11 June.
......	....	......	161.1	......	....	......	165.6	163.35	13 June.
......	....	......	160.7	......	....	......	162.9	161.80	11 June.
......	....	......	170.5	......	....	......	175.4	172.95	22 June.
......	....	......	147.84	......	....	......	153.34	150.59	31 May.

PHENOCHRON CURVES OF FLOWERING.

(Mean of "*first seen*" and "*becoming* common").



3.

Remarks on the Nova Scotian Phenochrons.

The Nova Scotian phenochrons are based on observations made in from ten to thirty observation stations in each county, on the 100 phenomena briefly indicated on pages 386 to 391 —preceding "Phenological Observations in Canada, 1900."

The observations, as a rule, are carried on by the pupils of the public schools, who are in competition with each other as to who will be the first observer of each phenomenon each year As these pupils often radiate as many as two miles from the school house each day, the observations "when first seen" are likely to be as early as the most favorable spot in each school section will allow. The second date recorded—"when becoming common"—is more a matter of judgment; but must practically be as near the date "when first seen" in the most unfavorable spots of each school section as can be determined.

The average differences between these two dates of flowering —"when first seen" and "when becoming common"—in each county of the Province for the ten plants selected for our study are as follows:

	Days.		Days.
Yarmouth	11.24	Guysboro	7.08
Shelburne	7.50	Cumberland	6.50
Digby	7.81	Colchester	6.56
Queens	8.06	Pictou	6.39
Annapolis	6.79	Antigonish	7.21
Lunenburg	6.74	Richmond	7.47
Kings	7.41	Cape Breton	4.69
Hants	6.28	Inverness	7.57
Halifax	8.35	Victoria	5.50

The average difference between the two dates for the Province is 7.175 days—about one week and four hours.

Owing to the mild winter weather in Yarmouth, some plants flower very early in sunny spots; but the general flowering is so retarded as to be less in advance of the rest of the Province than the "first" flowering. On the average, it appears that flowering becomes common about one week after the first blossoms are seen.

ORDER OF FLOWERING (MEAN OF "WHEN FIRST SEEN" AND "WHEN BECOMING COMMON") IN THE PROVINCE AND IN EACH COUNTY.

Mean flowering phenochrons for whole Province of Nova Scotia.	Order of flowering for Nova Scotia.	Order of flowering in each County.																	
		Yarmouth.	Shelburne.	Digby.	Queens.	Annapolis.	Lunenburg.	Kings.	Hants.	Halifax.	Guysboro.	Cumberland.	Colchester.	Pictou.	Antigonish.	Richmond.	Cape Breton.	Inverness.	Victoria.
113.01 Mayflower ....25 Apr.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
133.69 Red Maple ....14 May	2	4	4	3	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3
135.33 Blue Violet..........16 "	3	5	5	5	4	3	4	3	3	3	3	3	3	3	3	3	4	5	5
137.53 Dandelion...........18 "	4	2	3	4	3	5	3	5	4	5	4	5	4	4	4	5	3	4	2
137.86 Strawberry ....18 "	5	3	2	2	5	4	5	4	5	4	5	4	5	5	5	4	5	2	4
151.96 Wild Red Cherry.... 1 June	6	7	7	7	7	7	6	6	6	7	6	7	6	6	6	6	6	6	6
153.39 Blueberry............ 3 "	7	6	6	6	6	6	7	7	7	6	7	6	7	7	7	9	7	8	7
156.93 Apple .... 6 "	8	8	8	8	8	9	9	9	9	9	8	9	9	9	9	8	8	9	9
157.05 Buttercup............ 7 "	9	9	9	9	9	8	8	8	8	8	9	8	8	8	8	7	9	7	8
165.05 Lilac ....15 "	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

We see from the above that the *order* of the *ten* plants in our schedule and the tables, is not the exact order of flowering in the Province as a whole. The Red Maple and Blue Violet change places, as do also the Apple and the Buttercup. And the *order* for the Province is not that for each county. In Yarmouth and Shelburne, the Dandelion (4) and Strawberry (5) come ahead of the Red Maple and the Violet. The Blueberry (7) in the five South Southwestern counties comes ahead of the Wild Cherry (6); while in the case of the Apple (8) and Buttercup (9) they are in normal order while in the following counties they are mostly reversed.

The plate (page 392) of curves of the "mean" flowering phenochrons for 1900 of eight plants (two, the Maple and Violet, omitted because they would crowd 4 and 5) throughout the eighteen counties of the Province, which represent the "general

phenochrons" given in the last two columns of the tables preceding, show to the eye the general trend as well as several peculiarities of the time of flowering.

The general trend is seen in the later flowering as the counties lie north and east. There is a general conformity in this trend between the eight plants which fall into four groups, the Mayflower averaging 113.01 (24th April), the Dandelion and Strawberry 137 + (18th May), the Wild Cherry, Blueberry, Buttercup and Apple 154 + (4th June), and the Lilac 165 + (15th June).

A general trend is also seen in passing from Guysboro in the east back to Cumberland in the west; although moving on the whole northward, the flowering becomes earlier. A similar change takes place in passing from Richmond to Cape Breton. This latter is more remarkable, for Cape Breton is not only north but also east of Richmond. This seems to suggest that the observers in Guysboro and particularly in Richmond, might not have been so keen in the search for the first flowering as those in Cumberland and Cape Breton The small number of observers in these counties also suggests such a possibility. But by reference to the table, it will be seen, that as a rule, in counties where the observation stations are so numerous that ten could be selected from the coast, ten from the low inlands, and ten from the high inlands, the earliest flowering is on the low inlands, then on the coast, and latest on the highlands. It must be remembered, that there is a very great difference in the altitudes of what are called the low and high inlands in the different counties.

From such considerations, it is proposed in future to divide the Province into meteorological districts and sub-districts, instead of counties—the sub-districts being the coast belt, low inland belt and highland belt of each district; each district including a simple meteorological region or geographical slope.

Among the peculiarities shown by these curves are, for instance, the lateness of the Strawberry as compared with the

Dandelion in Shelburne, Queens and Guysboro; and its advanced appearance in Kings, Cumberland, Inverness and Victoria. Does the breath of the Atlantic retard the flowering of the Strawberry as compared with the Dandelion?

It also appears that the southern and sea surrounded Yarmouth is favorable to the early flowering of the Mayflower, but comparatively not so favorable to the Lilac. The manner in which the other curves intersect each other have also their explanations. But we are not yet in a position to be able to state them.

The stations of observations are, necessarily, not the same in each county each year. It is therefore possible that the phenochrons might be affected by a change in the relative number of coastal, inland and highland stations.

As all these observations are bound carefully into a large volume for each year, anyone having the time can use the facts recorded in any combination promising the most useful results. The present selection of ten plants, and the comparison of their flowering phenochrons in each county is merely a sort of preliminary or provisional testing of the possibilities and probable value of such observations—sufficient to interest the observers while they are developing accuracy—and a record of facts for future generalization.

In the second plate (page 397) there is a comparison of the "mean" flowering phenochrons of the Mayflower, Strawberry, Apple and Lilac, for the years 1898, 1899 and 1900.

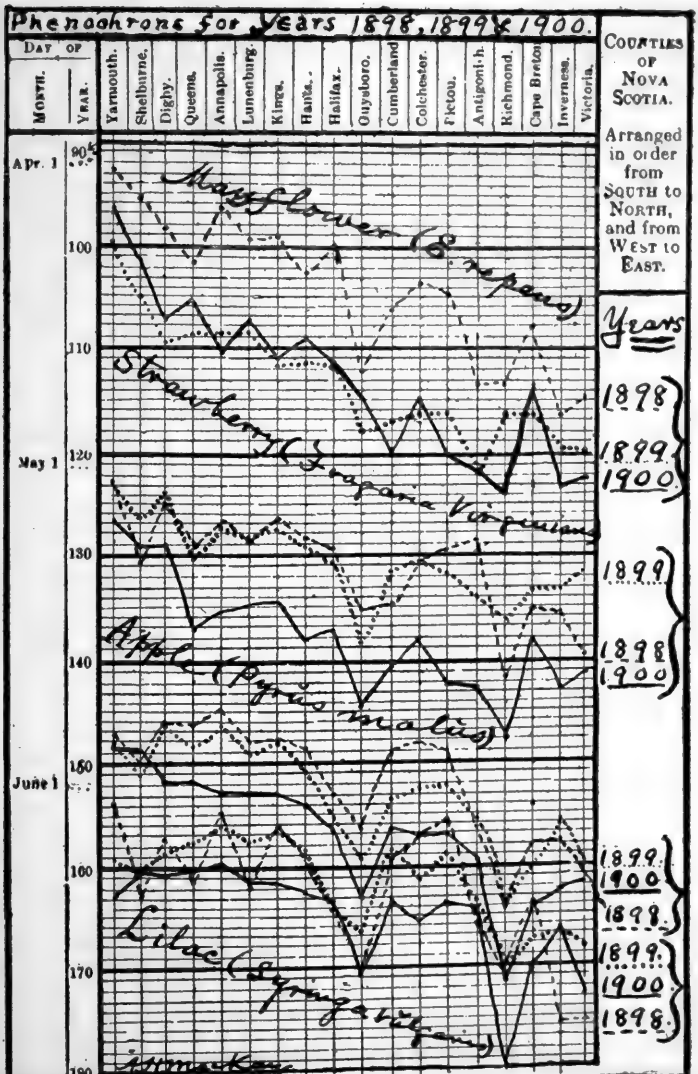
It indicates that the Spring of 1898 gave early promise, while those of 1899 and 1900 were later as measured by the Mayflower. The averages of these two years over the whole Province are nearly the same, the differences in the different counties being explicable as due to prevalent winds and degrees of sunshine.

As measured by the Strawberry, the first half of May 1900, was nearly a week more backward than in 1898 and 1899.

As measured by the Lilac, there was not much difference

PHENOCHRON CURVES OF FLOWERING.

(Mean of "*first seen*" and "*becoming* common").



between the three seasons in the state of vegetation during the first week or two of June.

But the continuous black line of 1900 is the lowest and latest for the Strawberry, Apple and Lilac; so that generally the month of May and the first week in June of this year was later from the "flowering" or estivation point of view.

It will be noticed on this table that the curves for the three years are to a great extent conformable, which demonstrates the important effect of the position of each county. The variations from conformability, are probably due to the differences in the winds and sunshine.

In the meantime we can make no mistake in recording and preserving as many accurate local phenological facts as possible. In a few years we shall be better able to estimate their value for many purposes.

In the future arrangements may be made for the publication of the observations of each year, as Dr. Ihne of Darmstadt is now doing for Europe. Our observations are more voluminous, however, and the cost of full publication would be great.

X.—RAINFALL NOTES, NOVA SCOTIA.—*By* F. W. W. DOANE, *M. Can. Soc. C. E., City Engineer, Halifax, N. S.*

(Read May 13th, 1901.)

If officials in charge of water works, water power and sewer systems are inclined to profit by knowledge acquired in the school of experience, the lessons presented to them during the year just closed have been severe and extraordinary ones. The long drought of 1900 will be remembered and referred to by meteorologists and others for many years to come. One of the severest ever recorded, occurred between the months of May and November. This condition was far-reaching, and extended throughout the whole of New England and New Brunswick, but does not seem to have reached Nova Scotia. The scarcity of water in public supplies as a result of the unusually dry season, was one of the most unpleasant features of the year. Water supplies, heretofore considered inexhaustible, failed. The fields and forests became thoroughly wilted and parched. The rural population suffered not only from the failure of wells, but more from the failure of their crops; and added to this, was the devastation and damage caused by numerous forest fires which covered large areas of country.

There were many superintendents of water works who, in the spring, contemplated with satisfaction the overflowing reservoirs and the abundant sources of supply which fed them, and who thought, no matter how much their fellow citizens consumed and wasted, nature had provided, and would continue to provide, sufficient water for all purposes. Before the summer had far advanced, the fast receding water lines on the reservoir embankments and the steady decrease of the "meadow stream and mountain torrent" warned them of the approaching short supply,

and not until late fall, and not even then in many localities, did the dreaded water famine come to an end.

With this condition all around us, Nova Scotia is to be congratulated. Precipitation reports from Yarmouth, Halifax, Truro and Sydney, show that the rainfall during the summer was about the average.

In St. John, New Brunswick, Mr. Murdoch, the engineer in charge of sewers and water works, states that the whole rainfall during the months of July, August and September, amounted to only 4.65 inches, or an average of 1.55 inches per month, which was the lowest in six years.

During the same months in Halifax, the rainfall was 10.908 inches, or very little below the average. Truro had a rainfall of 11.11 inches, Sydney, 8.76, and Yarmouth, 11.09, inches, while the total rainfall in Nova Scotia was above the average. The total precipitation at Sydney was the highest on record.

The last paper read before you on this subject (Trans., vol. ix, p. 279,) gave the maximum storms to December 31, 1896. Since that date new records have been made for minimum as well as maximum rainfall. In August, 1899, the rainfall at Halifax was 1.542 inches, the lowest on record for that month. In October, 1897, the rainfall was 0.746 inches, the lowest record for any month. In November, 1898, the highest rainfall for that month, viz., 10.248 inches, was recorded.

On the 18th of June, 1897, a heavy storm occurred at Halifax. It was reported by Mr. Augustus Allison, Dominion Government Meteorological Agent, as 0.577 inches, and 4.2 hours in duration. Mr. R. Cogswell gave the precipitation as 0.5 for the heaviest part of the storm. It is to be regretted that the actual time of the heaviest downpour was not noted. Several observers give the time as about 15 minutes, which would make the rate of fall two inches per hour.

Mr. James Little, meteorological observer at Truro, reports a thunderstorm of great severity, accompanied by heavy rain, on

August 1st, 1900. Rain began to fall at 11.30 a. m., and in 25 minutes measured 0.765 inches, a rate of 1.83 inches per hour. On the same day a second heavy rain and thunderstorm lasted from 3.15 p. m. to 4.30 p. m., the measurement being 0.85 inches, a rate of 0.68 inches per hour. No heavy rain was observed elsewhere in Nova Scotia on that date.

The tables appended show further details of the rainfall at Halifax, Truro, Sydney and Yarmouth during 1900:—

PRECIPITATION AT HALIFAX, N. S., 1900.

TABLE COMPILED FROM RETURNS OF MR. AUGUSTUS ALLISON, MET. AGENT, SHOWING DEPTH OF RAINFALL AND MELTED SNOW IN INCHES AND DURATION OF EACH STORM.

Day of Month.	January.		February.		March.		April.		May.		June	
	Hours.	Inches.	Hours.	Inches.	Hours.	Inches.	Hours.	Inches.	Hours.	Inches.	Hours.	Inches.
1	8.9	.800	1.0	.120	2.0	.020	4.0	.060	....	......	3.4	.208
2	1.2	.020	....	......	17.3	.692	....	......	....	......	6.2	.357
3	2 1	.140	....	......	2.0	.015	6.5	.310	5.0	.409	2.5	.162
4	....	......	2.0	.020	....	......	1.2	.048	5.0	.124	....	......
5	....	......	14.5	1.340	2.5	.060	....	......	1.3	.016	....	......
6	3.5	.060	3.7	.058	5.0	.030	7.0	.160	0.4	T.	....	......
7	....	......	4.0	.050	9.8	.620	13.7	.599	4.7	.142	....	......
8	4.6	.213	....	......	....	......	15.0	.330	4.0	.200	....	......
9	....	......	....	......	....	......	4.5	.060	7.5	.498	1.5	.110
10	4.0	.167	....	.020	7.1	.634	0.9	.010	....	......	....	......
11	....	......	....	......	3.1	.030	1.0	.018	....	......	....	......
12	15.7	2 364	....	......	....	......	....	......	....	......	....	......
13	3.4	.178	0.2	T.	10.2	.190	17.5	.528	5.0	.112	....	......
14	....	......	9.6	.842	21.5	1.502	7.5	.460	....	......	3.5	.284
15	....	......	....	......	2.5	.110	....	......	2.0	.040	4.0	.590
16	6.9	.262	3.6	.170	1.0	T.	....	......	2.9	.320	....	......
17	....	......	....	......	5.6	6.44	....	......	....	......	....	......
18	4.5	.010	7.5	.387	0.4	T.	9.5	.236	10.3	.370	....	......
19	6.3	.246	1.0	.020	2.0	.032	10.1	.440	17.8	.960	....	......
20	7 8	.567	....	......	15.1	1.332	3.0	.010	14.5	.966	....	......
21	13.5	1.212	....	......	1.0	T.	....	......	....	......	....	......
22	....	......	....	......	....	......	....	......	2.8	.077	2.6	.052
23	....	......	10.3	1.830	0.7	.019	8.0	.300	2.0	.020	3.5	.340
24	....	......	....	......	0.5	T.	2.0	.028	....	......	1 0	T.
25	1.7	.058	2.5	.400	....	......	4.0	.072	....	......	1.5	.060
26	11.6	1.272	2.0	.020	....	......	1.5	.058	....	......	....	......
27	1.0	T.	....	......	6.5	.125	....	......	....	......	....	......
28	....	......	....	......	....	T.	10.1	.100	....	......	1.5	.060
29	8.0	.630	....	......	0.5	T.	....	.112	....	......	1.2	.053
30	....	......	....	......	....	......	2.0	.010	....	......	3.0	.380
31	6.0	.333	....	......	10.1	.522	....	......	....	......	....	......
	....	8.532	....	5.277	....	6.577	....	3.949	....	4.254	....	2.656

PRECIPITATION AT HALIFAX, N. S., 1900.

TABLE COMPILED FROM RETURNS OF MR. AUGUSTUS ALLISON, MET. AGENT, SHOWING DEPTH OF RAINFALL AND MELTED SNOW IN INCHES, AND DURATION OF EACH STORM.

Day of Month.	July.		August.		Sept.		October.		November.		December.	
	Hours.	Inches.	Hours.	Inches.	Hours.	Inches.	Hours.	Inches.	Hours.	Inches.	Hours.	Inches.
1	2.0	.030	2.0	.038			0.5	T.				
2												
3												
4	6.1	.099	1.5	.030					2.0	T.	1.0	T.
5							2.8	.166	6.4	.556	21.1	1.730
6			0.2	T.			5.7	.264			1.0	.010
7												
8							4.0	.160	3.5	.380	1.0	T.
9		T.	4.4	.560			12.4	1.420	10.6	.970	1.5	.050
10			0.1	T.	1.0	.010	12.5	1.354	3.0	.142		
11			5.0	.440			10.5	.926				
12					7.5	.658	6.4	.560	9.0	.958	2.5	.020
13	2.5	.160							2.0	.070	3.6	.104
14		T.	9.5	.923			10.1	.937	2.6	.119	2.4	.166
15			2.5	.020			9.5	.518	2.5	.140		
16			6.7	.320	6.0	1.880	0.5	.010	4.1	.100	2.0	T.
17	3.5	.062	9.7	.650	4.1	.410	4.7	.642				
18	5.3	.113			7.0	.890			4.0	.133		
19	1.3	.016					1.5	.010	4.0	.184	4.0	.058
20			6.0	.502					8.7	.410		
21			0.7	.012	7.5	.156	1.7	.072	6.5	.430		
22			1.3	.040	12.5	.879			1.5	.090		
23					5.0	.130			2.9	.109		
24							2.5	.186			4.1	.278
25	3.9	.214	2.0	.130			0.9	.040	9.0	.331	2.0	T.
26	3.4	.878			0.7	.010			20.8	.679	2.1	.065
27	2.5	.300	1.0	.120					23.0	1.027		
28			1.6	.080		T.			1.5	.030	7.0	.150
29			2.0	.128	0.1	T.	1.3	.012			4.0	.120
30					1.0	.020	3.8	.018				
31											15.0	.570
		1.872		3.993		5.043		7.165		6.858		3.321

PRECIPITATION AT HALIFAX, N. S.

TABLE SHOWING THE NUMBER OF TIMES THAT THE TOTAL PRECIPITATION, EACH DAY FROM 1894 TO 1900, INCLUSIVE, HAS BEEN THE NEAREST TO A SERIES OF AMOUNTS RANGING FROM ONE-HUNDREDTH OF AN INCH TO FOUR AND A HALF INCHES.

YEARS.	AMOUNT IN INCHES.																									Total Rainfall for the Year.	YEARS.
	1/100	1/10	2/10	3/10	4/10	5/10	6/10	7/10	8/10	9/10	1	1¼	1½	1¾	2	2¼	2½	2¾	3	3¼	3½	3¾	4	4¼	4½		
1894........	50	42	13	16	9	7	5	5	5	6	2	2	2	....	....	....	....	....	1	....	....	....	....	....	....	45.808	1894
1895........	33	31	23	14	10	6	4	10	7	1	8	5	3	2	....	2	....	....	....	....	....	....	....	....	....	62.152	1895
1896........	45	30	19	12	10	8	5	7	6	3	2	3	6	1	....	....	1	....	....	1	1	....	1	....	1	69.862	1896
1897........	48	54	15	16	7	11	6	4	2	5	3	4	1	1	....	....	....	....	1	....	....	....	....	....	....	51.522	1897
1898........	46	34	20	17	14	9	6	6	6	4	3	8	2	....	....	1	....	1	....	....	....	....	....	....	....	60.480	1898
1899........	49	23	16	7	5	7	7	5	8	5	3	5	3	1	....	1	....	1	....	....	....	....	....	....	....	53.013	1899
1900........	38	47	18	13	12	6	12	4	2	6	5	5	2	2	1	1	....	....	....	....	....	....	....	....	....	59.697	1900
Totals ...	309	261	124	95	67	54	45	41	36	30	26	32	19	7	1	5	1	2	2	1	1	....	1	....	1	402.534	Totals.
Means....	44.1	37.3	17.7	13.6	9.6	7.7	6.4	5.9	5.1	4.3	3 7	4.6	2.7	1.0	.1	.7	.1	.3	.3	.1	.1	....	.1	....	.1	57.505	Means.

PRECIPITATION AT HALIFAX, N. S.

TABLE SHOWING, IN INCHES, MONTHLY RAINFALL DURING 1900, IN COMPARISON WITH MAXIMUM, MINIMUM AND AVERAGE MONTHLY PRECIPITATION, FROM 1869 TO 1900.

Month.	Year.	Maximum.	Minimum.	Average, 1869-1900.	Rainfall, 1900.
January	1895	10.131	....	5.757	8.532
"	1896	....	1.72	....	....
February	1870	10.34	....	4.892	5.277
"	1873	....	1.61	....	....
March	1878	10.274	....	5.449	6.577
"	1889	....	2.046	....	....
April	1889	7.403	....	4.075	3.949
"	1886	....	0.82	....	....
May	1886	8.82	....	4.170	4.254
"	1894	....	1.769	....	....
June..........	1874	7.92	....	3.675	2.656
"	1879	....	1.191	....	....
July	1896	8.729	....	3.918	1.872
"	1894	....	1.059	....	....
August........	1887	8.351	....	4.272	3.993
"	1899	....	1.542	....	....
September	1896	12.092	....	3.613	5.043
"	1878	....	0.800	....	....
October.......	1896	15.039	....	5.688	7.365
"	1897	....	0.746	....	....
November	1898	10.248	....	5.753	6.858
"	1882	....	1.392	....	....
December	1893	10.167	....	5.136	3.321
"	1875	....	1.61	....	....
Totals	1896	69.862	....	56.332	59.697
"	1894	....	45.808	....	....

PRECIPITATION AT HALIFAX, N. S.

TABLE SHOWING THE MONTHLY AND ANNUAL DEPTH OF RAIN AND MELTED SNOW, EXPRESSED IN INCHES; ALSO THE AMOUNT THAT HAS FALLEN FROM JANUARY 1ST TO THE END OF EACH MONTH, INCLUSIVE, DURING EACH YEAR.

Compiled from Observations and Records made by the Meteorological Agent of the Dominion Government.

YEAR.	January.	February.	January to February inclusive.	March.	January to March inclusive.	April.	January to April inclusive.	May.	January to May inclusive.	June.	January to June inclusive.
1869	4.53	4.38	8.91	7.95	16.86	2,57	19.43	5.57	25.00	3.92	28.92
1870	7.11	10.34	17.45	3.02	20.47	3.91	24.38	3.19	27.57	1.69	29.26
1871	3.73	5.88	9.61	6.16	15.77	4.88	20.65	2.59	23.24	2.96	26.20
1872	3.88	4.49	8.37	5.37	13.74	2.85	16.59	4.44	21.03	4.23	25.26
1873	7.83	1.61	9.44	4.09	13.53	2.86	16.39	2.34	18.73	2.96	21.69
1874	5.42	5 31	10.73	3.98	14.71	4.55	19.26	4.77	24.03	7.92	31.95
1875	3.48	5.90	9.380	2.11	11.49	3.38	14.87	3.96	18.83	4.07	22.90
1876	3.576	6.401	9.977	6.329	16.306	3.208	19.514	5.662	25.176	3.376	28.552
1877	4.200	1.809	6.009	8.666	14.675	3 801	18.476	4,024	22.500	3.841	26.341
1878	7.534	2.697	10,231	10.274	20.505	3.452	23.957	5.769	29.726	4.477	34.203
1879	4.400	3.001	7.401	6.044	13.445	3.481	16.926	4.687	21.613	1.191	22.804
1880	7.738	5.122	12.860	3.365	16.225	4.797	21.022	4.088	25.110	1.343	26.453
1881	3.607	5.329	8.936	6.556	15.492	3.498	18.990	2.460	21.450	5 308	26.751
1882	6.840	5.949	12.789	7.068	19.857	4.824	24.681	4.677	29.358	5.507	34.865
1883	4.930	3.860	8.790	4 941	13.731	3.703	17.434	8.613	26.047	3.322	29.369
1884	4.406	6.161	10.567	7 034	17.601	7.213	24.814	3.629	28.443	3.773	32.216
1885	6.388	5.090	11.478	3.889	15.367	3.520	18.887	3.282	22.169	2.749	24.918
1886	8.67	3.84	12.51	4.03	16.54	0.82	17 36	8.82	26 18	2.71	28.89
1887	7.656	6.735	14.391	4 629	19.020	6.386	25.406	2.126	27.532	2.121	29.653
1888	5.442	6.284	11.726	4.310	16.036	3.675	19.711	2.877	22.588	4.939	27.527
1889	4.391	6.181	10.572	2.046	12.618	7.403	20.021	3.871	23.892	3.755	27.647
1890	3.963	4.645	8.608	9.889	18.497	2.958	21 455	3.970	25.425	3 440	28.865
1891	8.383	8.740	17.123	2.685	19.808	4.010	23 818	4.195	28.013	4.131	32.144
1892	6 321	2.605	8.926	5.986	14.912	2.653	17.565	5.459	23.024	3.638	26.662
1893	4.781	5.979	10.760	2.303	13.063	4.209	17.272	5.054	22.326	1.753	24.079
1894	7.122	3.571	10.693	3.623	14.316	5.648	19.964	1.769	21.733	3.803	25.536
1895	10.131	4.605	14.736	5.931	20.667	3.956	24.623	4.089	28.712	1.827	30.539
1896	1.720	4.199	5.919	8.786	14.705	1.413	16.118	2.532	18.650	4.671	23.321
1897	5.896	2.898	8.794	5.470	14.264	6.211	20.475	4.613	25.088	6.070	31.158
1898	4.060	4.422	8.482	4.068	12.550	7.346	19.896	2 366	22.262	5.598	27.860
1899	5.083	3.613	8.696	7.178	15.874	3 278	19 152	3.677	22.829	3 875	26.704
1900	8.532	5.277	13.809	6.577	20.386	3 949	24.335	4.254	28.589	2.656	31.245

PRECIPITATION AT HALIFAX, N. S.

TABLE SHOWING THE MONTHLY AND ANNUAL DEPTH OF RAIN AND MELTED SNOW, EXPRESSED IN INCHES; ALSO THE AMOUNT THAT HAS FALLEN FROM JANUARY 1ST TO THE END OF EACH MONTH, INCLUSIVE, DURING EACH YEAR.

Compiled from Observations and Records made by the Meteorological Agent of the Dominion Government.

YEAR.	July.	January to July inclusive.	August.	January to August inclusive.	September.	January to September inclusive.	October.	January to October inclusive.	November.	January to November inclusive.	December.	For the Year.
1869	2.92	31.84	2.58	34.42	1 57	35.99	7.30	43.29	5.47	48.76	5.77	54.53
1870	3.21	32.47	2.20	34.67	3.33	38.00	6.85	44.85	6.28	51.13	6.06	57.19
1871	3.38	29.58	3.69	33.27	4.81	38.08	4.49	42.57	4.18	46 75	4.39	51.14
1872	2.88	28.14	6.82	34.96	1.41	36.37	4.88	41.25	6.65	47.90	6.16	54.06
1873	3.90	25.59	4.45	30.04	4.48	34.52	8.63	43.15	7.98	51.13	4.31	55.44
1874	2.29	34.24	3.37	37.61	5.04	42.65	2.46	45.11	3.58	48.69	5.49	54.18
1875	5.61	28.51	3.56	32.07	2.06	34.13	9.98	44.11	5.54	49.65	1.61	51.26
1876	3.914	32.446	1.909	34.375	6.094	40.469	4.076	44.545	7.397	51.942	3.164	55 106
1877	4.468	30.809	3.539	34.348	3.164	37.512	6.857	44.369	8.678	53.047	4.493	57.540
1878	1.483	35.686	3.127	38.813	.800	39.613	5.060	44.673	6.909	51.582	5.120	56.702
1879	3.843	26.647	4.827	31.474	2.600	34.074	4.760	38.834	4.837	43.671	4.029	47.700
1880	3.086	29.539	3.920	33.459	5.702	39.161	4.590	43.751	4.710	48.461	4.291	52.752
1881	3.177	29.935	3.062	32.990	3.105	36.095	4.206	40.301	4.420	44.721	7.034	51.755
1882	5.071	39.936	3.925	43.861	5.914	49.775	7.403	57.178	1.392	58.570	3.452	62.022
1883	3 540	32.909	5.342	38.251	3.864	42.115	5.841	47.956	3.478	51.434	6.678	58.112
1884	8.294	40.510	2.771	43.281	1.788	45.069	3.093	48.162	5.992	54.154	9.124	63.278
1885	5.817	30.735	3.001	33.736	2.497	36.233	6.280	42.513	5.423	47.936	8.693	56.629
1886	6.53	35.42	4.53	39.95	4.46	44.41	2.13	46.54	5.28	51.82	5.47	57.29
1887	2.045	31.698	8.351	40.049	3.308	43.357	3.058	46.415	6.718	53.133	4.120	57.253
1888	5.001	32 528	7.000	39.528	5.331	44.859	6 859	51.718	6.802	58.520	7.774	66.294
1889	2 668	30.315	2.633	32.948	1.399	34.347	4.179	38.526	7.145	45.671	2.988	48.659
1890	2.141	31.006	7.042	38.048	4.534	42.582	6.603	49.185	3.716	52.901	7.202	60.103
1891	4.003	36.147	3.385	39.532	3.052	42.584	9.621	52.205	2.388	54.593	4.076	58.669
1892	2.710	29.372	6.809	36.181	1.744	37.925	3.472	41.397	9.240	50.637	3.053	53.690
1893	4.757	28.836	5.954	34.790	4.391	39.181	5.640	44.821	3.760	48.581	10.167	58.748
1894	1.059	26.595	3.993	30.588	1.010	31.598	3.863	35.461	5.785	41.246	4.562	45.808
1895	3.924	34.463	5.502	39.965	2.491	42.456	5.627	48 083	8.223	56.306	5.846	62.152
1896	8.729	32.050	3.037	35.087	12.092	47.179	15.039	62.218	4.396	66.614	3.248	69.862
1897	3.661	34.819	5.185	40.004	1.169	41.173	0.746	41.919	6.051	47.970	3.552	51.522
1898	3.652	31.512	5.651	37.163	4.158	41.321	4.845	46.166	10.248	56.414	4.066	60.480
1899	5.747	32.451	1.542	33.993	3.201	37.194	6.191	43.385	4.590	47.975	5.038	53 013
1900	1.872	33.117	3.993	37.110	5.043	42.153	7.365	49.518	6.858	56.376	3.321	59.697

PRECIPITATION AT SYDNEY, N. S.

Table compiled from Returns of Mr. R. L. Laffin, Met. Agent.

Month (1900).	Precipitation. (1900.)	Year.	Total.
January	7.72	1893	33.49
February	5.60	1894	35.88
March	7.12	1895	38.81
April	6.66	1896	38.61
May	3.28	1897	29.23
June	3.44	1898	37.47
July	2.14	1899	39.58
August	2.54	1900	53.18
September	4.08	......	......
October	2.36	......	......
November	7.40	......	......
December	.84	......	......
Totals	53.18	Average.	38.28

PRECIPITATION AT TRURO, N. S., 1900.

Table compiled from Returns of Mr. James Little, Met. Agent.

Month.	Rainfall.	Snow.	Melted Snow.	Total.
January	4.37	16.7	1.30	5.67
February	2.66	20.0	1.52	4.18
March	3.55	18.7	1.44	4.99
April	3.23	15.2	1.17	4.40
May	3.60	......	......	3.60
June	4.55	......	......	4.55
July	2.51	......	......	2.51
August	6.06	......	......	6.06
September	2.54	......	......	2.54
October	6.22	0.5	0.04	6.26
November	4.97	8.1	0.63	5.60
December	0.89	25.5	1.96	2.85
Totals	45.15	104.7	8.06	53.21

PRECIPITATATION AT YARMOUTH, N. S., 1900.

From Returns of Mr. J. E. Murphy, Met. Agent.

Month.	Precipitation.
July	2.65
August	3.28
September	5.16
October	11.38
Total for year	60.32

TRANSACTIONS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1901-1902.

I.—On a Determination of the Freezing-point Depression Constant for Electrolytes.—By Thos. C. Hebb, M. A., *Dalhousie College, Halifax, N. S.*

(Communicated on 10th February, 1902, by Prof. J. G. MacGregor.)

In a paper read before the Royal Society of Canada,* Dr. MacGregor has described a method of combining the observations of different observers on the freezing-point depressions of electrolytes, for which the ionization coefficients at 0°C. are known, for the purpose of determining the depression constant for electrolytes. He also applied the method to a few sets of observations made in the Dalhousie College Laboratory, and found that the value so obtained agreed very closely with what one would expect from theory. In a subsequent paper† published by the Nova Scotian Institute of Science, he described a second method, and applied it to all the available data for electrolytes, in which both determinations of the freezing-point depressions, and of the ionization coefficients had been made. At his suggestion, I have applied the first method to the experimental material contained in the second paper, and to a few observations of my own as well, with the result given below.

The method is based upon the assumption, verified by experience, that the formula: $\delta = k(1-a) + la$—where δ is the

* Trans. Roy. Soc. Can. (2), Vol. 6, Sec. 3, 3, 1900-01.
† Proc. & Trans. N. S. Inst. Sci., Vol. x, p. 211, 1899-00.

equivalent depression, i. e., the depression of the freezing-point divided by the concentration, α is the ionization coefficient at 0°C. and k and l are constants—holds for electrolytes, in which the dilution is sufficient to make the mutual action between the molecules probably negligible. If, in the above formula, the concentration be expressed in gramme-equivalents per litre, the constant k will be the depression of the freezing-point caused by a gramme-equivalent of the undissociated electrolyte, and l will be the depression caused by a gramme-equivalent of the dissociated electrolyte.

Since this holds, it is evident that, if, for any electrolyte, we plot equivalent depressions δ against ionization coefficients α, we will at sufficient dilution get a straight line. Hence, knowing the equivalent depressions, and the ionization coefficients for different concentrations, for any electrolyte, we can draw in the ionization-equivalent depression curve. Then, finding that portion of the curve, which seems to be rectilinear, we can draw in the straight line, which best represents the results. The equation of this line from the above is $\delta = k(1-\alpha) + l\alpha$; and we may determine k and l by taking two points on the line, substituting the values of δ and α so obtained in the equation, and then solving the two simultaneous equations obtained.

Now it is clear that the constants, k and l, bear a simple relation to the depression constants, *i. e.*, to the depression of the freezing-point produced by a gramme-molecule of the undissociated electrolyte, and the depression produced by a gramme-ion of the free ions. Call these two constants m and i.

In the case of NaCl, KCl, HCl, NH_4Cl, KNO_3, HNO_3 and KOH, since each gramme-equivalent is a gramme-molecule, we have $k = m$; also, since each molecule breaks up into two ions each of which is equally effective in lowering the freezing-point, we have $l = 2i$.

In the case of $BaCl_2$, K_2SO_4, Na_2SO_4 and H_2SO_4, since each gramme-molecule contains two gramme-equivalents, we have $k = \frac{1}{2}m$; and we have $l = \frac{3}{2}i$, if we assume the molecule in

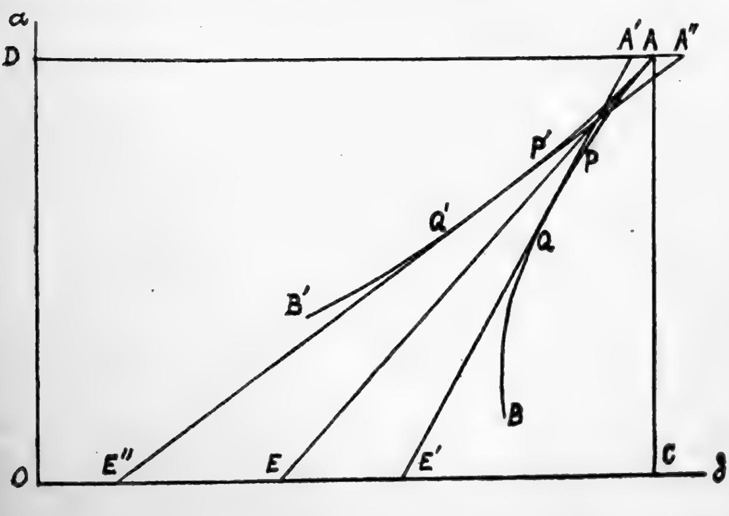
each case to break up into three ions, as, according to Prof. MacGregor's Diagram of Freezing-point depressions, it seems to do.

In the case of $MgSO_4$ each gramme-molecule contains two gramme-equivalents, hence $k=\frac{1}{2}m$; and since each molecule breaks up into two ions we get $l=i$.

In the case of H_3PO_4, if each gramme-molecule contains three gramme-equivalents, we have $k=\frac{1}{3}m$; also, if each molecule breaks up into two ions, as Loomis's and Jones's results seem to imply, we have $l=\frac{2}{3}i$.

As the constants, m and i, depend so simply on the constants, k and l, the accuracy of their determination will depend on the accuracy with which we can determine k and l. Dr. MacGregor has shewn that the values of l can be determined with a much greater degree of accuracy than can k.

Thus if AB or AB′ be the true curve representing the relation between δ and α—the curves for different electrolytes bend in different ways—then the equation $\delta=k(1-\alpha)+l\alpha$ will represent the straight line AE, *i. e.*, the tangent to the curve at infinite dilution if AC represents unity.



If in this equation $a=1$ then $\delta=l$ which is represented on the diagram by DA. Again if $a=o$ then $\delta=k$ which is represented by OE on the diagram. Now suppose that in drawing in our straight line we consider some portion as QP or Q′P′ as straight, and hence get the line as represented by our formula to be A″E″ or A′E′. In this case our l will be A″D or A′D instead of the true value AD, and k will be OE′ or OE″ instead of OE. The error in l is A″A or A′A, while that in k is EE″ or EE′. It is plain that AA″ or AA′ is less than EE″ or EE′, *i. e.*, that the accuracy with which l is determined is greater than that with which k is determined. Hence the values of i are affected with a smaller error than are those of m.

Since the depressions for dilute solutions are affected with a considerable error, the part of the ionization-equivalent depression curve near A is very untrustworthy. This is shewn by Dr. MacGregor in one of the papers referred to above. He has pointed out that the curves of the different observers for the same electrolyte deviate at great dilution, some to the right and others to the left of what their general course is at moderate dilution. Not only this, but the different observations of the same observer become very irregular as dilution increases.

As, therefore, the curves of the different observers have this rightward or leftward tendency—and sometimes to a great extent—as dilution increases, it is evident that we get better values of k and l, if we obtain them from a part of the ionization-equivalent depression curve, which corresponds to a concentration at which trustworthy determinations of the depressions can be made, than if we use the very erratic observations at high dilution. I have, therefore, in the determinations of k and l used only the observations on solutions of moderate dilution. As, however, some curves begin to curve rapidly as the concentration increases, even at an early stage, one has to use some discretion in choosing a part of the curve, which is least affected on the one hand by the natural bend of the curve, and on the other by the bend due to the error of method of the observer.

The data, as I have indicated, are taken from the second of the papers referred to above. Before, however, plotting the ionization-equivalent depression curve, I plotted in each case the equivalent depression against concentration, and drew in the smooth curve which best represented the results, so that approximately as many points fell on one side of the curve as on the other. In drawing in this curve, however, I did not use many of the observations—only those of the stronger concentrations. This was done in order to get rid, as much as possible, of the error due to the rightward or leftward tendency of the observations; for, had I plotted all the points and then drawn in the smooth curve which best represented them, these latter erratic points would have given a rightward or leftward tendency even to the part of the curve corresponding to the stronger concentrations. Hence, as a general thing, I discarded all but three or four of the observations on the stronger concentrations. In cases where I have kept more it is due to one of three things: (1) because the points were close together; (2) because there was very little rightward or leftward tendency to the ionization-equivalent depression curve, or (3) because the ionization-equivalent depression curve for these stronger concentrations had a rapid natural bend to it. The information in (2) and (3) was ascertained by a preliminary plotting of ionization coefficients against equivalent depressions. Having thus drawn in the smooth concentration-equivalent depression curve, I read off the values of the equivalent depressions corresponding to the given concentrations, and have given them in brackets alongside of the observations themselves.

I then plotted these corrected equivalent depressions against their corresponding ionization coefficients, and finding by inspection the portion of the curve thus obtained, which was straight, I drew in the straight line which I thought best represented the results. In drawing in this straight line I generally gave more weight to points corresponding to solutions of greater concentration. This straight line was then treated as pointed out above, and k and l were thus obtained.

The following table gives all the data together with the values of k and l thus obtained. The values of the ionization coefficients given were taken directly from the second of Dr. MacGregor's papers referred to above. The letters i and e which follow the coefficients indicate as to whether the values were obtained by interpolation or extrapolation. While the letters A, B, D and W refer to the observers Archibald, Barnes, Déguisne and Whetham.

TABLE 1.

Concentration. (gr eq /*l*.)	Ionization Coefficients at 0° C.	Equivalent Depression.
KCl. (Loomis.) $k=2.065$; $l=3.673$.		
.01	.943 i. B.	3.60
.02	.923 "	3.55
.03	.910 "	3.52 (3.528)
.035	.905 "	3.53 (3.519)
.05	.892 "	3.50 (3.498)
.1	.862 "	3.445 (3.450)
.2	.832 "	3.404
.4	.804 "	3.353
KCl. (Jones.) $k=2.180$; $l=3.678$.		
.04	.900 i. B.	3.5325
.0592	.885 "	3.5067
.078	.873 "	3.4923 (3.487)
.09646	.863 "	3.4688 (3.473)
.2	.832 "	3.4300
.28	.821 "	3.4107
KCl. (Raoult.) $k=1.846$; $l=3.652$.		
.05825	.904 e. W.	3.478
.1168	.878 "	3.431
KCl. (Abegg.) $k=1.344$; $l=3.719$.		
.0469	.895 i. B.	3.47
.0583	.887 "	3.45
.0697	.878 "	3.43

Concentration. (gr. eq. /*l*).	Ionization Coefficients at 0° C.	Equivalent Depression.
KCl. (Ponsot.) $k=1.920$; $l=3.687$.)		
.1468	.846 i. B.	3.413 (3.415)
.1688	.840 "	3.406 (3.404)
.2344	.827 "	3.392 (3.381)
.2456	.825 "	3.375 (3.378)
.2472	.825 "	3.378
.2544	.824 "	3.377
KCl. (Wildermann.) $k=2.034$; $l=3.689$.		
.03883	.900 i. B.	3.515 (3.5235)
.03884	.900 "	3.532 (3.5235)
.07652	.873 "	3.491 (3.489)
.07668	.873 "	3.487 (3.489)
KCl. (Hebb.) $k=1.755$; $l=3.695$.		
.0628	.882 i. B.	3.451 (3.465)
.1065	.859 "	3.415 (3.430)
.2121	.830 "	3.404 (3.375)
.3186	.817 "	3.340
NaCl. (Loomis.) $k=2.140$; $l=3.722$.		
.08	.860 i. B.	3.501
.09	.855 "	3.494 (3.493)
.10	.850 "	3.484 (3.485)
.20	.815 "	3.439

TABLE I.—*Continued.*

Concentration. (gr. eq. /*l*.)	Ionization Coefficients at 0° C.	Equivalent Depression.
NaCl. (Jones.) $k=2.050$; $l=3.726$.		
.0790	.861 i. B.	3.492
.0882	.856 "	3.483 (3.484)
.0973	.851 "	3.477 (3.476)
.1063	.848 "	3.469
.15	.831 "	3.447 (3.442)
.1925	.818 "	3.418 (3.424)
.2329	.805 "	3.414
Na′ l. (Abegg.) $k=.800$; $l=3.957$.		
.0439	.882 i. B.	3.57 (3.580)
.0653	.867 "	3.55 (3.537)
.0871	.856 "	3.50
.1083	.847 "	3.47
NaCl. (Arrhenius.) $k=1.992$; $l=3.697$.		
.194	.816 i. B.	3.54
.324	.781 "	3.51
NaCl. (Ponsot.) $k=2.000$; $l=3.728$.		
.1318	.836 i. B.	3.445
.1808	.821 "	3.418 (3.419)
.2016	.814 "	3.413 (3.411)
.2248	.808 "	3.403 (3.405)
.2288	.806 "	3.405 (3.404)

Concentration. (gr. eq. /*l*.)	Ionization Coefficients at 0° C.	Equivalent Depression.
HCl. (Loomis.) $k=2.095$; $l=3.643$.		
.01	.982 i. B.	3.61 (3.615)
.02	.972 "	3.60 (3.599)
.05	.955 "	3.59 (3.574)
.1	.933 "	3.546 (3.555)
.2	.910 "	3.565
.3	.897 "	3.612
HCl. (Jones.) $k=1.950$; $l=3.684$.		
.08127	.940 i. B.	3.5856 (3.580)
.1025	.933 "	3.5609 (3.568)
.1228	.928 "	3.5692 (3.565)
NH_4Cl. (Loomis.) $k=1.380$; $l=3.700$.		
.01	.951 i. D.	3.56 (3.585)
.02	.931 "	3.56 (3.540)
.035	.914 "	3.50
.05	.900 "	3.48
NH_4Cl. (Jones.) $k=2.050$; $l=3.692$.		
00997	.951 i. D.	3.6108
.0595	.892 e. D.	3.5143
KNO_3. (Loomis.) $k=1.580$; $l=3.682$.		
.025	.899 i. D.	3.46
.05	.876 "	3.41
.1	.832 e. D.	3.314
.2	.789 "	3.194

TABLE I.—*Continued.*

Concentration. (gr. eq. /*l*.)	Ionization Coefficients at 0° C.	Equivalent Depression.
K_2SO_4. (Ponsot.) *k*=.874 ; *l*=2.834.		
.0724	.731 i. A.	2.307
.0752	.726 "	2.301
.2295	.635 "	2.113 (2.115)
.2360	.633 "	2.110 (2.109)
.4140	.596 "	2.012 (2.010)
.4280	.594 "	2.002 (2.005)
Na_2SO_4. (Loomis.) *k*=1.100 ; *l*=2.815.		
.20	.624 i. A.	2.170
.40	.546 "	2.036
.60	.511 "	1.938
Na_2SO_4. (Arrhenius.) *k*=1.180 ; *l*=2.950.		
.234	.607 i. A.	2.205
.390	.549 "	2.095
H_2SO_4. (Loomis.) *k*= 731 ; *l*=2 826.		
.20	.598 i. B.	1.984
.40	.570 "	1.925
H_2SO_4. (Jones.) *k*=.792 ; *l*=2.767.		
.11358	.633 i. B.	2.0514 (2.042)
.15472	.612 "	1.9952 (2.001)
.19450	.598 "	1.9732
.2330	.586 "	1.9498

Concentration. (gr. eq. /*l*.)	Ionization Coefficients at 0° C.	Equivalent Depression.
H_2SO_4. (Ponsot.) *k*=.617 ; *l*=2.797.		
.2570	.587 i. B.	1.895 (1.897)
.2580	.587 "	1.899 (1.897)
.4476	.565 "	1.850
.4516	.565 "	1.849
H_2SO_4. (Wildermann.) *k*=1.080 ; *l*=2.565.		
.1358	.622 i B.	2.004
.1930	.599 "	1.970
$MgSO_4$. (Loomis.) *k*=.713 ; *l*=1.793.		
.04	.522 i. D.	1.277
.06	.485 "	1.237
$MgSO_4$. (Jones.) *k*=1 074 ; *l*=1 849.		
.015972	.614 i. D.	1.5590
.017940	.608 "	1.5496 (1.545)
.019904	.596 "	1.5323 (1.535)
.03950	.521 "	1.4912 (1.486)
.05872	.502 "	1.4391 (1.444)
H_3PO_4. (Loomis.) *k*=.654 ; *l*=1.1198.		
.03	.614 i. D.	0.94
.06	.513 "	0.893
H_3PO_4. (Jones.) *k*= 620 ; *l*=1.338.		
.019605	.669 i. D.	1.0967 (1.101)
.027705	.627 "	1.0721 (1.069)
.03279	.602 "	1.0522

TABLE I.—*Continued.*

Concentration (gr. eq. /l.)	Ionization Coefficients at 0° C.	Equivalent Depression.
K O H. (Loomis.) $k=2\ 256$; $l=3.516$		
.05	.943 e. D.	3.44
.10	.932 "	3.43
H N O_3. (Jones.) $k=2.640$; $l=3.765.$		
.03119	.958 e. D.	3.7179
.05103	.949 "	3.7076
K O H. (Jones) $k=2.019$; $l=3.699.$		
.01069	.964 e. D.	3.6296 (3 640)
.03163	.950 "	3.6263 (3.616)
.05174	.942 "	3.5756 (3.600)
.07481	935 "	3.6142 (3 590)
Ba Cl_2. (Loomis.) $k=1.198$; $l=2\ 743.$		
.02	.860 i. W.	2.495 (2.505)
.04	.820 e. W.	2.475 (2 465)
.1	.768 "	2.385
.2	.724 "	2.345
.4	.658 "	2.3275
Ba Cl_2. (Jones) $k=1.414$; $l=2.731.$		
.011964	.889 i. W.	2.5828 (2.590)
.01394	.880 "	2.5753
01592	.872 "	2.5754 (2.565)
.01788	.866 "	2.5560
.02	.860 "	2.550

Concentration. (gr. eq. /l.)	Ionization Coefficients at 0° C.	Equivalent Depression.
Ba Cl_2. (Ponsot.) $k=1,136$; $l=2.786.$		
.05520	.796 e. W.	2.446
.0620	.790 "	2.436
.0680	.785 "	2.426 (2.427)
.0774	.771 "	2.416 (2.415)
.2060	.717 "	2.316
.2095	.716 "	2.320 (2.315)
.2235	.710 "	2.309 (2.311)
.3100	.685 "	2.297
K_2 S O_4. (Loomis.) $k=1.118$; $l=2.752.$		
.02	.821 i. A.	2.46
.04	.772 "	2.38
.1	.705 "	2.271
.2	.645 "	2.1585
.4	.598 "	2.0335
.6	.583 "	1.9455
K_2 S O_4. (Jones) $k=.849$; $l=2.879.$		
.1357	.677 i. A.	2.231 (2.234)
.152	.668 "	2.208 (2.210)
.16765	.661 "	2.197 (2.192)
.1826	.654 "	2.178 (2.176)
.19685	.647 "	2.160 (2.162)
K_2 S O_4. (Abegg.) $k=901$; $l=2.771.$		
.01734	.829 i. A.	2.47
.0216	.815 "	2.43 (2.428)
.0258	.803 "	2.40 (2.402)
.0299	.794 "	2.385

The following table gives the values of the constants k and l given in table I. together with the values of m and i—*i. e.*, the depressions of the freezing-point due to a gramme-molecule of the undissociated salt, and that due to a gramme-ion of the dissociated salt—as obtained from them.

TABLE II.

Electrolyte.	Observer.	Ionization Constants.		Depression Constants for	
		k	l	Undissociated Molecules (m).	Free Ions (i).
KCl	Loomis	2.065	3.673	2.065	1.837
"	Jones	2.180	3.678	2.180	1.839
"	Raoult	1.846	3.652	1.846	1.826
"	Abegg	1.344	3.719	1.344	1.860
"	Wildermaun.	2.034	3.689	2.034	1.845
"	Ponsot	1.920	3.687	1.920	1.844
"	Hebb	1.755	3.695	1.755	1.848
NaCl	Loomis	2.140	3.722	2.140	1.861
"	Jones	2.050	3.726	2.050	1.863
"	Abegg	.800	3.957	.800	1.979
"	Arrhenius	1.992	3.697	1.992	1.849
"	Ponsot	2.000	3.728	2.000	1.864
HCl	Loomis	2.095	3.643	2.095	1.822
"	Jones	1.950	3.684	1.950	1.842
NH_4Cl	Loomis	1.380	3.700	1.380	1.850
"	Jones	2.050	3.692	2.050	1.846
KNO_3	Loomis	1.580	3.682	1.580	1.841
HNO_3	Jones	2.640	3.765	2.640	1.883
KOH	Loomis	2.256	3.516	2.256	1.758
"	Jones	2.019	3.699	2.019	1.850
$BaCl_2$	Loomis	1.198	2.743	2.396	1.829
"	Jones	1.414	2.734	2.828	1.823
"	Ponsot	1.136	2.786	2.272	1.857
K_2SO_4	Loomis	1.118	2.752	2.236	1.835
"	Jones	.849	2.879	1.698	1.919
"	Abegg	.901	2.771	1.802	1.847
"	Ponsot	.874	2.834	1.748	1.889
Na_2SO_4	Arrhenius	1.180	2.950	2.360	1.967
"	Loomis	1.100	2.815	2.200	1.877
H_2SO_4	Loomis	.731	2.826	1.462	1.884
"	Jones	.792	2.767	1.584	1.845
"	Ponsot	.617	2.797	1.234	1.865
"	Wildermann	1.080	2.565	2.160	1.710
$MgSO_4$	Loomis	.713	1.793	1.426	1.793
"	Jones	1.074	1.849	2.148	1.849
H_3PO_4	Loomis	.654	1.120	1.962	1.680
"	Jones	.620	1.338	1.860	2.007

One sees from an inspection of this table that the values of i, though they vary considerably, are in most cases not far from

the value expected from theory. In the case of the undissociated molecules, however, the variation of their values is much greater. As the depression produced by molecules is supposed on theoretical grounds to be the same as that produced by free ions, the difference between the variations of m and i is probably due to the different degrees of accuracy with which, as seen above, m and i are capable of determination.

If we assume, as is customary, that the depression produced by the molecules, whether they are undissociated molecules or free ions, is the same for all electrolytes in dilute solution, we can arrive at better values of both m and i by finding the mean values. This becomes obvious when we take into consideration the sources of error which affect the values of k and l. For the straight line, from which k and l are determined, may be either too high or too low; or it may be too much or too little inclined to the equivalent depression axis. The line may be too high or too low because of defective observations of depression, defective values of ionization coefficients, or the way in which I have drawn it in. So far, at least, as two of these sources of error are concerned, the resulting errors will in some cases be positive and in others negative; and in finding the average these errors will in part cancel one another. Defective inclination of the line may be due, in addition, to the characteristic error of the observer's method, which may be such as to make the curve at great dilution go off either to the right or the left as dilution increases, or to the natural bend of the curve itself which may be either to the right or left as concentration increases. The errors due to these sources will also be, in some cases, positive, and in others negative, and hence will practically neutralize one another on averaging.

The determinations of the above table are not all of the same order of trustworthiness. Some are based on freezing-point observations made by means of old methods; others on those of newer and more accurate methods. Some are based on many observations, others on few; some on observations in good agreement, others on more erratic series. In some cases, also, the ionization coefficients employed are more trustworthy than in

others If an estimate could be made of the relative value of the various determinations, the weighted mean would give a closer approximation to the true values of the depression constants, than can be given by a mere average. I have not attempted, however, to attach weights to the determinations, being unable to do so with any confidence.

Assuming that averaging will eliminate the greater part of the errors we get as the values of m and i, 1.932 and 1.851 respectively. The value for i is undoubtedly the more accurate of the two; and, as we assume that undissociated molecules have the same effect as free ions, the value of m is to be taken as 1.851 also. That the average value of m is so much greater than that of i may be due not only to the defects of the method employed in determining it, but to the fact that the bend of the curve of an electrolyte is more likely to be to the right than to the left, as concentration increases. For it is only where association of molecules takes place that it bends to the left.

Some of the sets of observations given in the paper, from which I have taken my data, I did not use. A few of these sets were so erratic that I could make nothing out of them. The other cases, however, had been worked out by Dr. MacGregor, and, hence, I did not think it worth my while to do so. If, now, I combine my results with those obtained by him, I will, with the exception of the few sets mentioned above, have made use of all available data. The mean values of m and i, as given by him, are 1.895 and 1.850 respectively and hence the values of m and i as given by averaging his mean values with mine are 1.913 and 1.851.

The above result is in agreement with that reached by Prof. MacGregor by means of the second method referred to above The conclusion he arrived at was that, for all the electrolytes examined, the curves of his diagram were consistent with the depression constant having a common value of about 1.85. That the two methods should give results which are not only in close agreement with one another, but are also in close agreement with the value of the depression constant given by Van 't Hoff's theoretical expression for it, must be regarded as of considerable interest.

II.—On the Determination of the Freezing-point Depressions of Dilute Solutions of Electrolytes.—By Thos. C. Hebb, M. A., *Dalhousie College, Halifax, N. S.*

(Read March 10th, 1902.)

Dr. MacGregor has shown,* that, if for any electrolyte curves be plotted using ionization coefficients as ordinates and the equivalent depressions of different observers as abscissae, the curves so drawn diverge, as dilution increases, some to the right and some to the left of what their general course is at moderate dilution. He has also shown, that this tendency to diverge is less for the results of Archibald and Barnes, both of whom worked in the Dalhousie Physical Laboratory. This indicates that the method they adopted was free from some source or sources of error which affected the methods of other observers. As they had not carried their observations to solutions of great dilution, he suggested that I should go over the ground with one or two electrolytes and see if, for higher dilutions, their results were borne out. This I have done for potassium chloride with the results given below.

I chose this electrolyte for the following reasons:—(1) It is one of the salts for which Whetham† has made determinations of the ionization coefficients for dilute solutions at 0°C.; (2) The rightward or leftward tendency, above mentioned, is most marked for this electrolyte; and (3) solutions of known concentrations are quite easily made up.

Salt.

The salt was obtained as chemically pure from Merck. On testing it, however, I detected free acid. This disappeared on once re-crystallizing and heating to constant weight. Solutions

* Proc. and Trans. N. S. Inst. Sci., Vol. X., p. 211, 1899-00.
† Phil. Trans., A, Vol. 194, 1900, pp. 321-360.

of it gave values of conductivity agreeing very well with those given by Kohlrausch.*

Water.

The water used, both in making up the solutions and in determining the freezing-point of water, was purified by boiling distilled water, containing a few grammes of barium hydroxide in a copper boiler and condensing it in a block-tin worm. It was kept in glass bottles, which had been used several years for that purpose. The conductivity of the water, obtained by once distilling, was never more than 1.25×10^{-6} at 18°C. expressed in Kohlrausch's new unit (ohm^{-1} $cm.^{-1}$).† The determination of the conductivity was made by means of Kohlrausch's method with the alternating current and telephone. The constant of the electrolytic cell used was determined by comparing the conductivities of known solutions at 18° with those given by Kohlrausch.‡ I did not try to obtain water of a greater degree of purity, for the amount of any electrolyte present to give it this conductivity is so small that the freezing-point would not be affected in the fourth place of decimals. This I have determined by using Kohlrausch's § table of conductivities, together with observations made on the freezing-point depressions of electrolytes of different observers. Of course there is the possibility of a non-electrolyte being present, but we may safely assume that the amount of it present is, at least, not greater than that of the electrolyte, and even twice the amount of salt present, which would be necessary to give the above conductivity, will not affect the freezing-point of water in the fourth place of decimals.

Solutions.

All solutions were made up at 0°C. The greater number of them were made by putting a known amount of the water-free salt in a 1000 c. c. flask, and filling it up with water at 0°C. A few of the diluter solutions were made from these by means

---

* Kohlrausch u. Holborn : Leitvermogen der Elektrolyte, 1898, p. 159, tab. 2.

† Kohlrausch u. Holborn : Leitvermogen der Elektrolyte, 1898, p. 1.

‡ *Loc. cit.*

§ *Loc. cit.*

of another flask of 200 c.c. capacity. Both flasks were calibrated at 0°C. The concentrations, in gramme-equivalents per litre of solutions at 0°C., were hence easily calculated. But in some of the cases I was not sure of the dryness of my salt, and hence determined their concentrations gravimetrically by precipitating the KCl of a known quantity of the solution with $Ag\ NO_3$.

Measurement of Freezing-Points.

The method used in determining the freezing-points was a modification of that used by Loomis.* The principal changes were: (1) the stirring was done mechanically and at a constant rate; (2) the stirrer was not simply of the ring form but had vanes attached to it; (3) the temperature surrounding the whole apparatus was kept within .5 degree of O°C. The work was done in a basement room of the college in which there was no source of heat, and experiments were only made when the temperature of the air could be kept at O°C. by raising the windows.

The freezing-apparatus consisted of three parts as follows: (1) an outer bath containing ice and water; (2) a bath which stood in this called the protection-bath, and which contained a mixture of salt water and snow, at a temperature of .005 degree centigrade below the freezing-point of the solution, whose freezing-point was being determined; (3) the freezing-tubes immersed in this, which contained the solution under experiment.

The freezing-tubes consisted of two glass tubes one inside the other, the outer being about 3.2 cm. in diameter. The space, of about 1 mm., between the two was kept uniform throughout by winding silk thread about the inner one at two distinct places. This air-space, together with one at the bottom of the tubes, caused by the bottom of the inner tube being re-entrant, kept an ice sheath from being formed on the wall of the tube. The two tubes were sealed together at the top, in order to keep moisture from getting in between them, and in order to have their relative positions always the same. These

*Phys. Review, 1, 199, 1893, and 9, 257, 1899.

tubes fitted tightly into the cover of the protection bath, and, as the outer tube was 30 cm. in length, they extended to a considerable distance into this bath. A cork made of vulcanite and pierced by three holes fitted into the inner tube. Through the hole in the centre of the cork a thermometer passed. It was fastened tightly, and in such a manner, that its bulb came within 2 cm. of the bottom of the inner tube. A stirrer passed through one of the other holes, while the third was kept for the introduction of an ice crystal. The last two mentioned holes were lined with platinum foil.

The stirrer which was made in the usual form with a ring at the bottom, was of platinum wire. This ring, which was smaller than the internal diameter of the inner tube, had fastened to it vanes of platinum foil. These were fastened on by platinum wire and extended in towards the centre. This form of stirrer I found to be much more effective in stirring than the ring commonly used.

In order to guide this stirrer, and in order to keep the thermometer in the centre of the freezing-tube, another cork, of rubber, was fastened on to the thermometer, some distance above the highest point reached by the solution when the thermometer was in position in the freezing-tube. Through this cork there were two holes—one for the stirrer and one for the introduction of an ice crystal. These holes were lined with glass tubing.

The above arrangement kept the stirrer from scraping against the sides of the freezing-tubes. And, in order to keep it as much as possible from rubbing against the sides of the holes in the corks, a link was introduced in the part of the wire outside of the tubes. This allowed it to hang in a perfectly vertical position.

The protection bath was 38 cm. in height and 13 cm. in diameter. Its cover consisted of a brass plate through which passed the freezing-tubes, a thermometer and a stirrer. This stirrer consisted of a wire shaft, which had two rings fastened to it—one for the upper and one for the lower portions of the mixture. The rings held vanes of tin. This kept the mixture

well stirred, and any change in temperature was quickly recorded by the thermometer.

It was so arranged that both these stirrers—viz., the one in the protection bath and the one in the freezing-tubes—should have the same stroke. Hence they were both fastened to a slider on a vertical guide-post. This slider was worked by a crank vertically above it. The axis carrying the crank was turned by a hot-air motor. The stroke of the crank was equal to the stroke required by the stirrers.

The two thermometers—viz., the one in the protection bath and the one in the freezing-tubes—were both of the Beckmann form, and were graduated to .01 degree. The one used in the freezing-tubes had been calibrated at the Physikalisch-Technische Reichsanstalt, Berlin. The value of its degree—its length being about 5.4 cm.—was given to the third place of decimals. As, however, it had been tested with its bulb at 0°C. and its scale at 15°C., I had to make a correction due to the fact that I used it with its scale also at 0°C. In the corrected form the value of the degree was correct. For some time before it was used, and while it was being used, it was kept hanging in a vertical position with its bulb and scale approximately at zero. This precaution is indispensible, as the constancy of the thermometer depends on it. This thermometer was read by means of a microscope, which was firmly mounted on an adjustable stand. The eye-piece of the microscope contained a micrometer scale, thirty-seven divisions of which corresponded to .01 degree. As half divisions were easily estimated I could read to .0001 degree. To get a clear imagine of scale and mercury, a small incandescent lamp, driven by a current from several Samson cells, was placed, when a reading was being taken, directly behind the thermometer. As, however, the mercury and scale are at different distances from the microscope, one cannot focus the both at once. Hence I always made a reading with the mercury focussed, for it was quite easy to estimate the centre of the blurred image of the scale line. In the course of my experiments, I found out how important it was to have the microscope always inclined at the

same angle to the thermometer. This one sees when he takes into consideration, that the distance between the mercury column and the scale, which is back of it, is at least 120 times as great as the smallest distance read on the scale. In order to keep the microscope always at the same inclination to the thermometer, I had two arms rigidly attached to the microscope—one above and one below it. Before a reading was taken, the stand of the microscope was so adjusted that the arms touched the thermometer.

Directly over the top of the thermometer was placed an electric hammer, driven by a current from a Samson battery. It gave quick, sharp taps and, hence, prevented the mercury from sticking at one place.

The following method was used to find the convergence temperature. The apparatus, as described, was set in order with a mixture at O°C. in the protection bath, and water in the freezing-tubes, and then the stirring was begun and kept running until the apparatus arrived at a state of thermal equilibrium. With the apparatus working at 50 complete strokes per minute, I found it to be .005 degree above that of the protection bath. Hence in all of my determinations of freezing-points, the temperature of the protection bath was kept .005 degree below the freezing-point of the solution under experiment—it having been approximately determined beforehand. This convergence temperature is much smaller than that found by other experimenters. Its smallness may be due to two things: (1) the freezing-tubes may be too easily affected by the protection bath, or (2) the apparatus may be free from friction and other sources of heat. I am fully convinced that its smallness in my case was not due to the former, but due to the fact that the amount of friction was very small, and that the air temperature was O°C.

The following was the method used in making a determination of the freezing-point. The approximate freezing-point of the solution having been found, the temperature of the protection bath was brought to be .005 degree below this. The portions of the apparatus in contact with the solution were then

thoroughly cleaned and rinsed with the solution. The inner freezing-tube was then filled up to a mark on its side—this mark being about 2mm. above the highest position reached by the stirrer. The cork bearing the thermometer was put in its place, the tubes were then placed in a mixture of snow and salt, and the solution kept continually stirred until its temperature fell to .3°C. below its freezing-point. They were then placed in position in the protection bath, and the stirring was begun. When the mercury, which rose very slowly, arrived at .1 degree below the freezing-point, an ice-crystal was introduced through the holes in the corks. After the mercury became stationary, the tapping of the electric hammer was begun and lasted for half a minute. The stirring was then stopped, the light put into position, and a reading made with the microscope. The stirring was then begun again and after a few minutes a second reading made. With my apparatus, I found no difficulty whatever in getting the mercury to remain stationary for at least five minutes. In cases where more than one observation was made on the same solution, the mean value was taken. As it was only the depressions that I wanted, I found the freezing-point of water immediately before or immediately after the above determination. The water used was of the same degree of purity as that used in making up the solutions. Other conditions, such as the introduction of the ice-crystal, were kept the same in both cases. If the barometer was varying rapidly, the freezing-point of water was taken immediately before and after that of the solution, and the mean taken.

The depression is the difference between the freezing-point of water and that of the solution under consideration. I found by experiments performed on different days, that of a series of depressions, a single value varied from the mean value by not more than .0005 degree. As this would be large for dilute solutions, I was unable to deal with solutions of greater dilution than I have used.

To correct for the change in concentration, due to the introduction of an ice-crystal .1 degree below the freezing-point, I made use of Raoult's method* for determining the depression

* Ztschr. f. phys. chem., 27 613, 1899.

when the over-cooling is zero. For this purpose I took a solution and found its depressions for different over-coolings. These depressions I plotted as ordinates against the over-coolings as abscissae. This gives practically a straight line which, if produced to cut the depression axis, cuts off a portion from it representing the depression when the over-cooling is zero. Raoult has shewn that the following relation holds for solutions of different concentrations

$$C^1 = C(1 + KS)$$

where C^1 is the observed depression for over-cooling S, C is the depression for over-cooling zero, and K is a constant. Hence, determining C and S for different solutions, and knowing K to hold for all solutions, we can find C in each case. I determined K to have the value .02. Hence it can easily be seen that for an over-cooling of .1 degree the values of the depressions will be .02% too great.

The ionization coefficients are taken from a paper by Whetham.* Since he only carried his concentrations to .03 gramme-equivalents per 1000 grammes of solution, I have extended the curve under guidance of extrapolated values given by Dr. MacGregor.† He obtained his extrapolated values by plotting, alongside of one another, the ionization coefficient-concentration curves for 0° and 18°—the latter being obtained from data given by Kohlrausch.

In the following table the concentrations are given in gramme-equivalents per litre of solution at O°C. The depressions, which have been corrected for over-cooling, as pointed out, are given in degrees Centigrade. The ionization coefficients are for O°C., and the equivalent depressions are the depressions in degrees Centigrade divided by the concentration in gramme-equivalents per litre of solution at O°C. The letters *i* and *e* after the coefficients shew whether they were obtained by interpolation or extrapolation.

---

* *Loc. cit.*

† Proc. and Trans. N. S. Inst. Sci., Vol. X. p. 218, 1899-90.

The table also contains the values of the depression constant, *i. e.*, the lowering produced by each gramme-molecule or gramme-ion of the electroyte in solution. It has been calculated by aid of the expression: $\delta = i\,(1 + a)$ where δ is the equivalent depression, i is the constant and a is the ionization coefficient. This formula only holds for electrolytes such as KCl where the gramme-molecule is equal to the gramme-equivalent and the molecule breaks up into two ions.

TABLE I.—KCl. (74.59).

Concentration. (gr. eq. /*l.*)	Depression of Freezing-Point.	Equivalent Depression.	Ionization Coefficients at 0° C.	Depression Constant (i).
.004124	.0151	3.66	.979 i.	1.850
.006207	.0228	3.67	.972 "	1.863
.006363	.0233	3.66	.972 "	1.857
.009310	.0341	3.66	.964 "	1.867
.009544	.0344	3.60	.963 "	1.836
.01009	.0362	3.59	.962 "	1.829
.01060	.0381	3.60	.961 "	1.833
.01085	.0395	3.64	.960 "	1.858
.01473	.0531	3.61	.952 "	1.847
.01514	.0549	3.63	.952 "	1 857
.01862	.0673	3.614	.946 "	1.857
.01909	.0688	3.60	.946 "	1.852
.020596	.0738	3.583	.943 "	1.844
.02402	.0860	3.580	.938 "	1.847
.03031	.1086	3.583	.932 "	1.854
.03161	.1131	3.578	.930 e.	1.854
.05541	.1950	3.519	.906 "	1.846
.05583	.1958	3.507	.906 "	1.840
.05673	.2001	3.527	.905 "	1.851
.05770	.2033	3.523	.905 "	1.849
.07383	.2578	3.492	.894 "	1.844
.07408	.2597	3.505	.894 "	1.851

In these results I have not continued my determinations to as concentrated solutions as I would have liked, but I was unable to do so on account of lack of cold weather. On the other hand, it would be useless for me to attempt to deal with diluter solutions than I have used, for my possible error is too great.

The values of the depression constant seem to oscillate about the value 1.85 and if the mean be taken we get 1.849. This is the value arrived at by two methods suggested by Dr. MacGregor. The one he applied* and the other I applied† to a considerable number of data.

If from the above table we plot concentrations as ordinates against equivalent depressions as abscissae, we get points which, though they do not lie on a smooth curve, can be represented by drawing a smooth curve through them in such a manner that as many points fall on one side of it as on the other. If we draw in this curve we find that it is convex towards the concentration axis. Further, if we plot alongside of it similar concentration-equivalent depression curves for other observers, we find that in all cases their curves lie nearer the concentration axis than mine, although no two of them pursue exactly the same course. That the values of my depressions are greater than those of other observers might be expected, for I am not aware that any of them worked with their air temperature at zero. Also the fact, that the values of the depression constant, as obtained from my results, agree so well with what is expected, would lead one to suppose that my values of the equivalent depressions are not too great.

The following table will give some idea as to how Loomis',‡ Jones',‡ and my concentration-equivalent depression curves lie. I have roughly drawn smooth curves through each observer's results, and then read off the results for the different concentrations.

---

* Proc. and Trans. N. S. Inst. Sci., Vol. X., p. 211, 1899-00.

† Proc. and Trans. N. S. Inst. Sci., Vol. X., p. 409, 1901-02.

‡ Not having access to their papers, I have taken the data from a paper by Prof. MacGregor: Proc. and Trans. N. S. Inst. Sci., Vol. X., p. 211, 1899-00.

TABLE II.

Concentration. (gr. eq. /*l.*)	Equivalent Depression.		
	Loomis.	Jones.	Hebb.
.075	3.470	3.495	3.495
.05	3.50	3.518	3.528
.03	3.528	3.553	3.570
.02	3.550	3.575	3.598
.01	3.60	3.605	3.64
.005	....	3.665	3.67

If now we plot ionization coefficients as ordinates, against equivalent depressions as abscissae, it is generally assumed that at great dilution we shouid get a straight line. My results are too erratic to lie on a straight line, but the general course of them is no doubt a straight line, and does not tend to either the right or left, as do the curves of others—at least up to the concentration .01. Above this it seems to have a slight rightward tendency, but not nearly as great as Jones'. Of all the observer's results to which I have access, and this includes Loomis, Jones, Raoult, Abegg, Ponsot and Wildermann,* there are none which give a curve as high or higher than mine. Jones' curve at the lower part seems to coincide with mine, but from the concentration of about .08 to .007 it goes to the left of mine, and from this on it passes away to the right. Loomis' curve is to the left of both Jones' and mine and has the leftward tendency, but looks as if it would pass off to the right, if dilution were carried far enough. Abegg's curve is to the left of Loomis'. It starts at a concentration of .07, runs parallel to mine for a space and then passes off to the right. Wildermann's curve has the leftward tendency, while Raoult's seems to be inclined towards the right. In plotting all the above curves I have used Whetham's coefficients.

Hence it appears to me that my results have bourne out—at least to a large degree—what Archibald's and Barnes' results seem to imply.

*These data are all taken from MacGregor's paper cited above.

III.—The Progress of Geological Investigation in Nova Scotia.—By R. W. Ells, LL.D., F. R. S. C., *of the Geological Survey of Canada.*

(Read 13th January, 1902.)

Probably in no part of the Dominion of Canada is there a more interesting field for geological research than is found in Nova Scotia and in the sister province of New Brunswick. The formations range from the top of the Triassic to the lowest known rocks, presumably the fundamental gneiss, and there is a large development of the strata peculiar to the Carboniferous, Devonian and Cambrian systems, in all of which important geological and economic problems are presented.

It has been found impossible to classify and arrange the different rock formations of the maritime provinces in accordance with the scheme of nomenclature laid down more than half a century ago by the Geological Survey of the state of New York, and subsequently adopted by Sir W. E. Logan for the province of Ontario and Quebec. In consequence of this difficulty, the necessity has arisen of placing large groups of strata in divisions which have been designated by local names, and this feature has been the cause of some confusion to many persons who are not familiar with the localities and the points of structure peculiar to each.

Too often, also, there has been an attempt made to parallel the rock formations there found with those which they are supposed to represent in England on the one hand, and in distant portions of the United States on the other, ignoring the possibility that the succession of life forms on the globe in early years may not have moved forward simultaneously over the whole surface, but that their distribution may have followed some law of evolution or development which has not yet been sufficiently considered. Geological problems in connection with certain

formations in the maritime provinces have thus occasionally presented features difficult to reconcile with those which are found in supposed similar formations elsewhere, when the attempt at interpretation has been made purely from the standpoint of the contained fossils by those who were not familiar with the local conditions of structure or the nature of the rock formations which are there presented.

In the present paper no attempt will be made to discuss the different views which have been put forth from time to time regarding the horizons of the several rock groups in Nova Scotia. To do justice to this aspect of the subject would extend the limits of the paper to great length. It is proposed, therefore, to give merely a brief statement of some of the work which has been done in this field, with a short notice of the men who have been largely instrumental in elucidating the principal points of structure throughout the province.

Much of this early work in the field was carried out by two Nova Scotians, viz., Dr. Abraham Gesner, a name well-known in the central portion of the province, and by Sir William Dawson, a native of Pictou. Both of these men, under many difficulties, partly inseparable from that early date, devoted much of the time taken from their otherwise arduous duties to the study of the somewhat complicated geological problems there presented.

The task which these two distinguished men, who may well be styled the pioneers in geological science in the eastern provinces, thus voluntarily assumed in the first half of the last century was no easy one. Even in England, the actual work of a geological survey had scarcely been commenced. The nomenclature of the science was in its infancy, and the many helps towards deciphering the writings in the great book of the rock formations, which are now available to the students of geological structure, were altogether, or almost entirely, lacking.

When these men began their work the country was comparatively but little opened up for settlement. Roads were few and far between when once the main lines of communication

were left behind, so that the facilities for detailed careful examination and comparison were rarely found. That so large an amount of really valuable information was obtained in those early days is matter for gratulation and clearly proves that these early students of the earth's crust were not only careful observers but were imbued with the true scientific spirit.

Probably the earliest description, from the scientific standpoint, of the rocks found in Nova Scotia, is contained in a somewhat lengthy paper, contributed to the American Journal of Science by Messrs. Jackson and Alger, two leading American geologists, in 1828-29. This paper was illustrated by a sketch map of a portion of the province, which is probably the first attempt at a geological map issued in Canada.

Without going into details as to the points of structure which are there described, it may be said that this paper contains much interesting information relative to the trap formations of the Bay of Fundy, and to their contained minerals. The gypsum deposits, found along the south side of the Basin of Minas, also received a fair amount of attention, and there is a good description of the iron ores which occur in portions of the South Mountain range at different points.

At that early date the long list of names now employed to distinguish the many formations to which the various rocks which form the earth's crust are now assigned was not formulated. The use of the term Primitive for certain granite masses was common, and these were supposed to represent the oldest group of rocks. The term Transition was also employed to designate certain altered sediments which are in contact with the granites at different points; but such names as Silurian, Devonian, Carboniferous and Triassic were not yet invented.

The terms trap, sandstone and slate are, in this early paper, in general use, but details of geological structure are almost entirely wanting. The article, however, is interesting from its very full description of the trap formation found in the North Mountain range, and to some extent valuable from the description therein contained relative to the mode of occurrence

and distribution of some of the leading economic minerals. In this connection the iron ores of the South Mountain range which are seen at Nictaux and Bear River are regarded as probably continuous throughout the entire mountain range, passing to the rear of the village of Horton, and possibly continuing further east to connect with theiron deposits found in Pictou county.

Considerable information is also given as to the coal and copper deposits in Cumberland, Colchester and Pictou counties, in the latter of which the coal mines, now of so much importance, were then just being opened.

Probably the most important of the early writings on the subject of Nova Scotian geology are from the pen of Dr. Abraham Gesner. The first of his publications to appear has the date 1836, and is entitled, " Remarks on the Geology and Mineralogy of Nova Scotia." The volume contains the results of his observations throughout the province during several preceding years, and is the first attempt made to place the geological formations there found in regular order. Gesner arranged the several rock groups into districts, and placed the granites, which he found so persistent along the Atlantic coast, in the Primary district, regarding these as his oldest division. A second belt which he outlined throughout a great part of the central area of the province, and which consisted largely of slates, he styled the Slate district, and regarded them as more recent in age than the granite.

These were succeeded northward by a great series of reddish sandstones, shales, and some slaty beds, which now include formations from the Silurian to the Trias, both inclusive, which he termed the Red Sandstone district. This division embraced also what is now known as the Coal formation, while to the great ridge of volcanic rocks, including basalts, diabase and amygdaloids, which are found chiefly in the North Mountain range, he gave the name of the Trap district.

This classification, it will be observed, was based largely on physical and lithological characters and upon the predominant rock masses in each.

This volume of Gesner's was accompanied by a small map of the province on which the limits of the several divisions were outlined as then understood.

Of Dr. Gesner, it may be truly said that he was a remarkable man for his times. The collection and preparation of the great mass of facts contained in his first book must have involved a large amount of hardship in the field and in his study, and in the preface he states that "amidst the arduous duties of a laborious profession, and under the annoyance of perpetual interruption, most of the following pages have been written; or during the silent hours of midnight, when the labours but not the fatigues of the day had departed."

Gesner's subsequent publications relative to the subject of Nova Scotia geology may be briefly mentioned. In 1843 an important paper was read before the Geological Society of London, Eng., which was accompanied by a geological map of a large portion of the province, and this shews a marked advance as compared with those which had previously appeared; and a similar paper was published in the London Mining Journal in 1845.

A second volume styled "The Industrial Resources of Nova Scotia" appeared in 1849. This contained two chapters devoted to the geology and mineral resources of the province. In this volume it will be readily noticed that a great advance has been made in geological science since the date of the first book in 1836. The several formations have been fairly well arranged in accordance with modern ideas of nomenclature, though the work was necessarily done on the broad scale. The rocks were arranged under seven heads, as follows:—

1st. The granites or hypogene rocks of the south coast, including the syenites and traps. 2nd. The stratified non-fossiliferous rocks of the interior, now known as the gold-bearing and other associated slates, which he called Cambrian, in which classification they still remain. 3rd. The fossiliferous clay slates, with greywackes, which he styled

Silurian, the term being still held as applicable to a large part of these sediments. 4th. The overlying series to the base of the Carboniferous, regarded as of the age of the old Red sandstone or Devonian. 5th. The Carboniferous proper or Coal formation. 6th. The New Red sandstone and the intrusive or igneous rocks associated, now regarded as probably of Triassic age; and 7th, the overlying drift or boulder formation.

The arrangement of so many groups of rock formations throughout the province in such a manner as to be fairly well sustained by more recent and detailed investigation, conclusively establishes the fact that in Dr. Gesner the province possessed a geologist of no mean order, having a wonderful grasp of the difficult problems everywhere presented in connection with the rock structure in the eastern provinces, and indicating a marvellous capacity for scientific investigation.

During the years from 1838 to 1843, Gesner, at the request of the government of New Brunswick, made a comparatively close study of the rock formations found in that province. The results of his work appeared in five separate reports of great interest, the terms employed to designate the several rock groups corresponding closely with those which he employed in his work in Nova Scotia. He also published a volume on the general resources of New Brunswick which appeared in 1847, in which several chapters were devoted to the geological features there observed, so that it will be readily seen the life work of Dr. Gesner was of great importance and value to both the eastern provinces.

As a sample of his style of writing, the following, taken from his description of the Cornwallis valley, as contained in his first volume, 1836, may be given:—

"Before the visitor descends from the South Mountains near Kentville, let him take a view of the extensive valley before him. On the north side rise those mountains of basaltic columns, which, with proud elevation, line the coast of the Bay of Fundy, protecting the beautiful and fertile Township of Cornwallis, and all the settlements situated at their base from the bleak north-

wester, so well-known, and so little admired in Nova Scotia. Let him turn his eyes towards the western horizon, and as far as vision extends, the red sandstone supports the soil of the almost level country before him, while rocks of different classes are thrown up like walls on each of its sides, affording shelter from southern and northern gales; and lastly, let a glance be taken at the bustling little village beneath his feet, and he will admire not only the grand and beautiful spectacle before him, but also the infant town below, prepared to afford him those refreshments his stroll will have rendered necessary. In the neighbourhood of Kentville, the new red sandstone is in contact with the old red sandstone, the members of the mountain limestone and coal groups being deficient. The great bed of iron, represented as occupying a place throughout the whole South Mountain range, has not yet been discovered south of that village; but from the occurrence of detached pieces of the ore, iron pyrites, and the carbonate of iron at Beech Hill, no doubt can be entertained of its uninterrupted existence, even farther eastward than that place."

An important feature in the history of Nova Scotian geology was the visit of Sir Charles Lyell who, in 1842, made a geological excursion through portions of the province. In this work he was aided by Dr. Gesner and also by Sir William Dawson, the latter at that time a young man of about twenty-three years of age. The results of this visit of Sir Charles Lyell are given in his book, "Travels in North America," published in 1845. He paid much attention to the group of rocks which had been classified in large part by Gesner under the head of the red sandstone division, and as a consequence of his examination these were separated into three portions styled respectively, the upper carboniferous, the productive coal measures, and the lower carboniferous or gypsiferous formation. The last named was placed in its true position beneath the coal measures, while the soft red sandstones, so conspicuous around the shores of Minas Basin, were regarded as an upper division and regarded as probably belonging to the Trias. The visit of Sir Charles Lyell was therefore important as serving to determine more clearly the true horizons of this important series of rocks.

Among the workers in the eastern portion of the province who have aided materially in elucidating points of structure may be mentioned the name of Mr. R. Brown. From his intimate connection with some of the leading coal mines of Sydney, Mr. Brown enjoyed great facilities for studying the rocks of the Carboniferous formations in that area, and he has contributed much valuable information regarding the arrangement and distribution of these rocks for that portion of the province. Some of the results thus obtained have appeared in the Journal of the Geological Society of London, the first article being apparently printed in 1853, as well as in more recent publications.

The association of Sir William Dawson with Sir Charles Lyell in 1842, greatly stimulated the love of the former for scientific investigation, and for many years thereafter much of his spare time was devoted to the study of the rocks in his native province. From his position as Superintendent of Education, which appointment he held for some years previous to his removal to Montreal as principal of McGill University, he was enabled to visit many localities where interesting problems of structure were presented.

Sir William was an early contributor to the scientific journals, since we find a communication from his pen in the Journal of the Geological Society for 1842 on some geological phenomena which he had observed in Prince Edward Island. Many of his papers, more especially in the early years of his work, were read before the Geological Society, of which body he soon was appointed a fellow. Up to the date of his death, which occurred near the close of 1899, his pen was rarely idle, the list of his published writings reaching a total of nearly four hundred, in which are included many books of much interest, some of which dealt exclusively with scientific matters, while others had a wider scope.

The first of these volumes relating to the geology of the maritime provinces was his "Acadian Geology," the first edition of which appeared in 1855. A second edition, much enlarged, was published in 1868, and this was added to by a supplement

in 1878 and another in 1891, in which the latest information on the subject was supposed to be incorporated.

The "Acadian Geology" has for many years been regarded as a standard work in the field of scientific research, though, as more detailed investigations have been carried out, several statements regarding the structure of certain formations have of necessity undergone revision. A large portion of Sir William's life work was spent in the study of fossil plants, in which line of investigation he was justly regarded as an eminent authority. These studies embraced the fossil remains found in the Devonian and Silurian of Gaspé and New Brunswick, and in the Carboniferous rocks of all the maritime provinces, as well as the fossil plants found in the newer formations of the Pacific slope. Like Gesner, Sir William Dawson may rightly be considered as one of Nova Scotia's most distinguished sons in the line of scientific investigation.

Among other zealous workers in the geological field in Nova Scotia must be mentioned the name of the Rev. Dr. Honeyman. Formerly a minister of the Presbyterian church and settled in Antigonish, his fondness for geological study early led him to a close investigation of the complicated rock formations which are found in the eastern part of the province. Afterwards, being transferred to Halifax, he became the curator of the Provincial Museum. Here his field of work became somewhat enlarged, and his researches extended over many parts of the province. The results of his field work appeared in a number of interesting and valuable papers, many of which were published in the Transactions of the Nova Scotian Institute of Science, though others were read before the scientific societies both of England and the United States.

The first of these contributions by Dr. Honeyman on the geology of Nova Scotia was apparently presented before the Literary and Scientific Society of that province in 1859, and from that date to the time of his death in 1889, articles from his pen appeared at frequent intervals. Though the chief field of his labours for many years was the classic ground of Arisaig, where

probably his best work was accomplished, his eyes were open to the natural phenomena which are everywhere presented to him who cares to read the story of the earth.

A full list of his publications has apparently never been published, and the collecting of these in proper order is a duty yet devolving upon some one of those with whom he was intimately associated in the scientific work which has been and is still being carried on in the Acadian provinces.

Prior to the admission of the eastern provinces into the Canadian confederation the work of the Geological Survey did not extend east of Quebec.

Almost the earliest work, however, of the first director, Sir William Logan, was the examination and measurement, in 1843, of the celebrated Joggins section on the western coast of Cumberland county, embracing a total measured thickness of 14,570 feet of Carboniferous strata, in which were included a large part of the Lower Carboniferous formation, the Millstone-grit, the Productive Coal-Measures, and the Upper Carboniferous in part. The work so ably done at that early date has since been revised by several other workers in the field, notably by Sir William Dawson, the results of whose examinations, stated in much detail, will be found in the second edition of the Acadian Geology, 1868. The section as originally published has ever remained as the standard basis of classification for the rocks of the Carboniferous system in the maritime provinces.

With the advent of Confederation in 1867, the work of the Geological Survey was extended to New Brunswick and Nova Scotia. In 1868 Sir William Logan and Mr. Edward Hartley began a detailed examination of the coal fields in Pictou county which was carried on till the death of the latter at the close of 1870. The results of these examinations in the Pictou coal-field were of the greatest importance, and the coal basin was mapped with great accuracy.

In consequence of the importance which the gold-fields of Nova Scotia had assumed, Dr. Selwyn who had been appointed director of the Geological Survey in 1869, made a somewhat

detailed examination of that district in 1870, and published a valuable report on the subject in the annual volume of the Department for 1870-71. In this report the gold-bearing rocks of the province were fully described and compared with those found in the province of Quebec, and also with those of the gold-fields of Australia in which district he had already worked for some years as Director of the Geological Survey of that colony. In 1871 Dr. Selwyn also made a study of the iron-ore deposits of the Londonderry district, the results of which were stated in the Report of the Department for 1872-73.

In 1870 work was commenced in the Springhill coal basin by Mr. Scott Barlow, and carried on continuously by him till the close of 1878. In addition to mapping the Springhill areas, Mr. Barlow's work extended over a large portion of the county of Cumberland, the results appearing in several important reports to the Geological Survey Department. In 1873 Mr. Walter McOuat began a series of surveys in parts of the same field, but more particularly in the area to the north-east of that assigned to Mr. Barlow, which were carried on till his death at an early age in 1875. The results of his explorations also appear in several valuable reports addressed to the same Department.

In 1872 Mr. Charles Robb, after several seasons spent in New Brunswick, began a systematic exploration of the Cape Breton coal-fields. In this work he was associated with Mr. Hugh Fletcher, who, on the retirement of Mr. Robb in 1875, assumed control of and completed the mapping of the coal-basin. The explorations were thereupon extended and the whole of the island carefully surveyed and mapped in great detail.

Upon the completion of this work, Mr. Fletcher's field of operations was transferred to the main land, and the same detailed series of surveys which had been inaugurated in Cape Breton were there continued. In this way much of the northern and eastern portions of the province have been carefully mapped and the geological details indicated with great minuteness, including the counties of Guysboro, Antigonish, Colchester and Cumberland, and large portions of Hants and Kings. The minuteness

of detail shewn in such of these map-sheets as have been published, attest the scientific training of their author and the extreme care which has been taken in their preparation. Much attention has been devoted to the accurate mapping of the important coal-basins of Pictou and Cumberland counties, and to the determination of the economic value of other deposits of economic minerals which are found in the area.

The mapping of the great belt of rocks along the Atlantic coast, including the slates, quartzites and granites, which in the early days of Gesner were styled Primitive and Transition, and in which the gold mines of the province are principally located, has been carried out along similar lines by Mr. E. R. Faribault, also of the Geological Survey staff. In addition to the general maps, shewing the distribution of the several rock formations of that district, a valuable series of map-sheets shewing the detailed structure of the principal gold areas has been prepared. Some of these have been already published, while others are in course of preparation and are of inestimable value to the mining community of the province. The complicated series of rocks which were broadly outlined half a century ago by Gesner and Dawson have thus been worked out in the greatest detail, and the several geological divisions indicated in the clearest manner.

Among those who have done more or less work in the province, it may be said that the writer of this article, in 1884, in connection with his work in south-eastern New Brunswick, spent some weeks in tracing out the formations in the area between the Bay of Fundy and Northumberland Straits in the preparation of the map of Cumberland county.

In 1891 and 1892, Mr. R. Chalmers made a series of careful examinations in connection with the surface deposits of Cumberland county, with particular reference to the glaciation of that district; and in the years from 1890 to 1896, Dr. L. W. Bailey, of the University of New Brunswick, carried on a somewhat extended examination of the southern and western portions of the province, including the counties of Digby, Yarmouth, Queens and Annapolis. A detailed report of the work thus done,

accompanied by a map of the area, was prepared and published in the annual volume of the Geological Survey for 1896, in which the leading geological formations were outlined and many important facts relating to the structure and mineral resources were given. The detailed mapping of portions of this district is still in progress, in order that the map-sheets of that portion of the province may conform with those already published of the northern and eastern divisions.

Valuable papers have also appeared from time to time from the pen of Mr. H. S. Poole, for many years connected with important mining operations in the Pictou coal-fields, which afforded him excellent opportunities for the study of the rocks of the Carboniferous system, and also from Dr. E. Gilpin, of the Department of Mines, Halifax, who has ably dealt with certain points of structure presented by the rocks of that district, and also with many questions relating to the occurrence of economic minerals at many points throughout the province.

In connection with Acadia College, Professor Haycock has recently published two valuable papers, dealing largely with the question of local geology, which are of much interest. In the area about Wolfville and along the Gaspereau Valley, as well as in connection with the rocks of the North Mountain range, there is a most interesting field for investigation which has been as yet scarcely touched. It is to be hoped that this area will now receive that attention from local geologists which it well deserves.

In a paper of this kind it is, of course, very evident that many points of great interest must be omitted. The merest outlines of the subject have of necessity been stated, and there are other names which have been associated to a greater or less extent with the work of investigation, to which but slight reference can be made. Among those who have thus contributed papers relating to the geological structure and mineral resources of the province at a comparatively early date, may be mentioned by Mr. J. Campbell of Halifax, whose reports on the gold-fields, in 1863 are of much interest, and Dr. H. Y. Hind of Windsor,

who, from 1869 to 1872, published several articles on the same subject. Papers of more or less importance relating to the gold of Nova Scotia, have also been printed by Mr. C. Fred Hartt in 1864 and by Mr. H. F. Perley in 1865, both in the Canadian Naturalist of Montreal, and by Professors Marsh in 1861 and Silliman in the American Journal of Science.

Among contributors to the literature pertaining to the coal-fields of the province, in addition to those already referred to, may be mentioned Mr. H. Poole who contributed two papers, one in the Journal of the Geological Society of London, 1853, the other in the Canadian Naturalist in 1860, and Professor J. P. Lesley, whose elaborate article on the structure of the Cape Breton areas was published in the American Journal of Science for 1863.

From the pen of the late Dr. H. How of Windsor, several valuable articles appeared between 1857 and 1866, principally in the Transactions of the N. S. Institute of Natural Science. These, for the most part, described the occurrence of valuable and sometimes rare minerals, found at different places in the province. Various publications, more particularly relating to the occurrence and determination of fossils from various localities have also appeared from time to time, both in the official reports of the Geological Survey and in various scientific journals, and represent the work of Messrs E. Billings, T. C. Weston, D. Honeyman, H. Poole, H. M. Ami and others. These can only be thus briefly alluded to, since the aim of this paper has been to give broadly some slight sketch of the leading workers in this field, and a brief statement of the results of their labours. The details of the subject may well be left to others, who through a more intimate acquaintance with the progress of geological science in the province, both as regards men and localities, are better fitted than the writer for the task of elaboration.

IV.—On the Upper Cambrian Age of the Dictyonema Slates of Angus Brook, New Canaan and Kentville, N. S.—By H. M. Ami, D. Sc., F. G. S., *of the Geological Survey of Canada.*

(Read 10th February, 1902.)

In his "Acadian Geology," second edition, 1868, p. 563, Sir William Dawson figures *Dictyonema Websteri* and places it as a Silurian (Upper Silurian) species. In describing the slates from which the type-specimens of this species were obtained he writes: "Passing from the Cobequid Mountains to the slate hills of the south side of the Bay" --meaning the Bay of Fundy —"in Kings County, we find slates not very dissimilar from those of the Cobequids,"—which he had described on the previous page, 562—"in the promontory northward of the Gaspereau River. Here the direction, both of the bedding and of the slates structure, is N. E. by S. W.; but the planes of cleavage dip to the S. E., while the bedding, as indicated by lines of different color, dips to the N. W. These slates with the quartzite and coarse limestones, are continued in the hills of New Canaan, where they contain crinoidal joints, fossil shells, corals, and in some beds of fawn-coloured slate, beautiful fan-like expansions of the pretty *Dictyonema* represented in fig. 196. Very fine specimens of this fossil were found by the late Dr. Webster of Kentville. It was the habitation of thousands of minute polypes, similar apparently to those of the modern *Sertularia.* The general strike of the rocks in New Canaan is N. E. and S. W., and they extend from that place westward to the Nictaux River. Westward of Nictaux River, as already mentioned in describing the Devonian, the beds of the Upper Silurian, as well as those of the last mentioned formation, are nterrupted by great masses of granite which form the hills along the south side of the Annapolis River, from a place called

Paradise to Bridgetown, and with some interruptions nearly as far as the town of Annapolis."

In my "Synopsis of the Geology of Canada,"* the following paragraph refers to the Silurian of the region in question as presented and systematized from the accepted and available sources of information :—

"In the County of Annapolis, Nova Scotia, and in the vicinity of Nictaux, Silurian strata occur, including the *Nictaux* iron ore beds and the *Torbrook* sandstone formation, whilst near Kentville, the *Kentville* formation is seen as well as on Angus Brook in the Gaspereau Valley, also at New Canaan with *Dictyonema Websteri*, Dawson."

Slates holding *Dictyonema Websteri*, Dawson, and thus known to occur: (1) At New Canaan, the type locality; (2) At Kentville, N. S., and (3) along the upper portion of the valley of Angus Brook, a small stream entering the Gaspereau River between the village of Gaspereau and the Avon River shore.

The general section of the rocks holding the specimens of *Dictyonema* and the truly Silurian fossil-bearing strata of the district, in which corals and encrinites and brachiopods occur, as furnished me by Sir William Dawson some years ago, distinctly showed that he connected the two in a general way only, following the inclination and strike of the strata in that part of Nova Scotia which have been affected by the same physical forces that disturbed rocks belonging to various members of the Palæozoic succession. It is thus seen that the intrusive masses of the district have affected not only the Cambrian strata, but likewise the later deposits, exclusive of the rocks of the Horton and its underlying co-formation, the Gaspereau formation, and the Grand Pré formation of later Triassic Age.

Heretofore, the slates which have yielded the specimens of *Dictyonema Websteri* have been invariably referred to the Silurian system, but more recent examination of the type specimens of *D. Websteri*, have revealed a remarkable resemblance to, and the close affinity of this species with the

* Trans. Royal Soc. Can., 2nd Ser., 1900-1901, Vol. VI., Sect. VI., p. 203.

Dictyonema flabelliforme, Eichwald, which finds a synonym in the *D. sociale*, Salter, a characteristic Upper Cambrian fossil.

In his "Niagara Fossils," Part I, Graptolitidæ of the Upper Silurian, Prof. J. W. Spencer writes of *Dictyonema Websteri*, Dawson:—

"This beautiful frond occurs at New Canaan, Nova Scotia, in fawn-colored slate of the Upper Silurian System. It is celluliferous on one side, and in appearance it is more closely related to *D. retiforme* than to *D. gracile*."

In comparing the microscopical characters of *D. Websteri* with those of *D. flabelliforme*, Eichwald, especially as they are presented and illustrated in Carl Wiman's classic work† the relative size and proportions of the peculiar rope-like structure of the main skeleton in the rhabdosome is clearly discernible, so that there is practically no doubt as to the identity of the two species.

It will therefore now be necessary to refer *D. Websteri*, as a synonym of *D. flabelliforme*, Eichwald, and to refer the Kentville formation, not to the Silurian (Upper) System, but to the Cambrian. In fact, the slates of the Kentville formation of Kings and Annapolis Counties in Nova Scotia, are equivalent in age or are taxonomically similar to the slates of Barachois, and associated localities in the Mira Series of Cape Breton, as well as to the *Dictyonema* slates of Navy Island, near St. John City, and the slates of Eel River, near Benton, in New Brunswick. All of these are referable to the Upper Cambrian.

The first *rapprochement* made between *Dictyonema flabelliforme* and *D. Websteri*, took place some two years ago when the *Dictyonema*, obtained by Prof. L. W. Bailey, near Benton, along the Eel River, in York Co., N. B., was compared with the specimens of *D. Websteri*, at present in the collections of the Geological Survey Department, and they were found to be so closely related as not to be practically separable. From specimens of *D. flabelliforme*, obtained on Navy Island, and kindly

* See Bull. Mus. Univ., State of Missouri, vol. I, no 1, p. 26, St. Louis, 1884.

† Ueber die Graptoliten, Bull. Geol. Inst. Upsala. Pl. x, figures 13 and 14, p. 55, 1892?

loaned to me for study and reference by Prof. L. W. Bailey of the University of New Brunswick, it was readily seen that the Benton specimens were also Upper Cambrian in age.

In order to ascertain definitely whether *D. Websteri*, Dawson, from New Canaan, was identical with *D. flabelliforme*, the type specimens of the former, which formed part of the Dawson collections in the Peter Redpath Museum of McGill University, were sought, and kindly loaned to the writer by Prof. F. D. Adams. These are preserved on two slabs of more or less hardened sericeous or glossy red shale or slate, and scattered over the surface of the slates in a rather fragmentary state of preservation, except in one specimen, from which the illustration on p. 563, (fig. 196,) was very probably made when the "Acadian Geology" was prepared.

From a careful study of all the material in hand, the writer is satisfied that the upper beds of the Cambrian System are thus represented in that portion of Nova Scotia where the *Dictyonema flabelliforme* beds of Kentville, New Canaan, and the Gaspereau Valley, (south side,) occur.

We thus find that the zone or horizon of *Dictyonema flabelliforme*, Eichwald, occurs at the following localities in Canada, which may consequently be referred to the Upper or Neo-Cambrian :—

(1.) Matane, Quebec, South Shore of St. Lawrence River.
(2.) Cape Rosier, Gaspé, Que., near Lighthouse.
(3.) Barachois, Cape Breton, Nova Scotia.
(4.) Navy Island, near St. John, New Brunswick.
(5.) Shales near Benton, above Fredericton, York County, New Brunswick.
(6.) New Canaan, Annapolis County, Nova Scotia.
(7.) Kentville, Annapolis County, Nova Scotia.
(8.) Angus Brook, Gaspereau Valley, Kings County, Nova Scotia.

Associated with *Dictyonema flabelliforme* at Angus Brook, are found obscure remains of a Bryograptus, allied to *B. Kjerulfi* from the Upper Cambrian of Scandinavia.

V.—NOTES ON DR. AMI'S PAPER ON DICTYONEMA SLATES OF ANGUS BROOK, NEW CANAAN, AND KENTVILLE, N. S.—BY HENRY S. POOLE, F. G. S., F. R. S. C., ETC.

(Read 10th February, 1902.)

When handed Dr. Ami's paper to read at this meeting, I was requested to make some remarks on it. I comply, but only do so with the understanding that I can speak with no authority, nor am I able to properly discuss it.

It may be of interest to some present to know that the fossil in question, *Dictyonema,* is classed with the curious fossil forms, Graptolites, and the modern Sertularia among the order of Hydrozoa. These beautiful zoophites are like branching plants and are found on temperate coasts. They have two rows of cells on the horny branches.

The *Dictyonema* also reminds one of the coral *Fenestella* which occurs in the limestones at Windsor and Brookfield in lower carboniferous rocks ; but the branches of Fenestella which frequently biforate are connected by narrow bands, with characteristic round cellules on a calcareous frond. The skeleton of *Dictyonema* is striated, serrated and horny. The animals of this class are jelly-like, radially symmetrical, living in colonies, and building up for the common good these horny structures which have been preserved as fossils while all trace of the animal has disappeared. The allies of the *Dictyonema,* the Graptolites, reached their maximum in Silurian times, and disappeared with that age after evolving many varieties of form and habit.

Sir A. Geikie speaks of *Dictyonema* as a characteristic fossil of the primordial zone in Scandinavia, where it is associated with allied but doubtful forms. In Canada it also occurs at Point Levis and other places, with graptolites.

It certainly is new to place these Dictyonema beds as Cambrian, and it is not easy to understand how Dr. Ami came to change the views he expressed before the Royal Society in 1900, without visiting the locality, unless he has been influenced by the examination lately made by Mr. H. Fletcher. I should like to know what Mr. Fletcher has to say of the stratigraphy and the age of these fossils. I know he has suspected some rocks in this lccality to be Cambrian, and that he got Mr. Faribault to go over the ground with him. Mr. Faribault, as we all know, has for years made a study of the Cambrian in Nova Scotia, and has written a bulletin of the greatest practical value to miners, on the structure of these rocks and the manner of occurrence in them of auriferous leads and paystreaks. So much has this pamphlet been appreciated that our Mining Society has issued nearly 1000 copies to miners, engineers and students. I may also say I hestitate to accept Dr. Ami's interpretation of the paragraph he quotes from "Acadian Geology," in which Sir W. Dawson says: "These slates . . . are continued in the hills of New Canaan, where they contain crinoidal joints, fossil shells, corals, and in some beds of fawn-colored slate, beautiful fanlike expansions of the pretty *Dictyonema*." Therefore before accepting a supposition that he meant otherwise than he wrote, I would like to know the views of Mr. Fletcher. Prof. Haycock, of Wolfville, has been with Mr. Fietcher in this field, and has besides made explorations on his own account. What are his views? If the crinoid, shell and coral beds mentioned are associated with the Dictyonema beds, the series of fossils they probably yield should determine beyond doubt the age of *Dictyonema Websteri*. These associate fossils are not enumerated.

Sir W. Dawson, it is true, spoke of them as *Upper* Silurian, but then he classed the overlying beds of Bear River as Devonian. Dr. Honeyman put them down as Lower Silurian, and the overlying beds as Upper Silurian, and thus maintained the same relative positions.

Dr. Ami quotes from his "Synopsis of the Geology of Canada," in which many references are made to Nova Scotian

geology. Some of these have brought out papers in reply in our own "Transactions," in the Ottawa "Naturalist," the proceedings of the Mining Society, etc. The comments make it clear that the groups of beds he then proposed as *typical* formations, and the names he suggested, have not been generally acceptable.

As issued, this Synopsis has some paragraphs not easy of interpretation, *e. g.*, he says: "The most fossiliferous limestones, as at Windsor and Brookfield have been referred to the *Windsor formation.* . The Windsor is followed or accompanied by an extensive series . . to which the term Millstone Grit has been applied. The *Westville formation* is equivalent to the so-called Millstone Grit, below the productive coal measures.—Unconformably above the Westville is the *New Glasgow formation*, which is overlaid by *Smelt Brook formation.* Then follows the *Pictou formation*, overlaid by the *Cape John formation.*" Then we are told—"The Cape John rocks, sometimes called Permo-carboniferous, are well developed in Prince Edward Island . . . and probably represent the equivalent of the Windsor and Westville formations of Nova Scotia." If not a mistake of the printer, a veritable round robin—a complete cycle of formations here exists.

Further on he says, "It is very possible, however, that the Cape John formation and associated formation may be equivalent to 'Permian' strata in other portions of North America or Europe;" thus he leaves the situation still obscure.

To a student of our Cambrian rocks the presence of fossils in any members or any reputed members of the series is of interest. Discoveries of a few have been reported, some of which have been adjudged to be only concretions. But Mr. Prest has found in the quartzites of Bedford and Lockport Island radiating obscure structures called *Astropolithon.* Dr. Selwyn, late Director of the Geological Survey in 1871 discovered in the dark slates at the Ovens in Lunenburg County, markings which Mr. Billings determined to be *Eophyton*, similar to that found at St. John, N. B. Worm tracks, I believe, have been before seen, but the specimen I show is

from the syncline at Green Bank, Point Pleasant Park, Halifax. I obtained it last autumn, but could not detect other structures in the same beds.*

D. Websteri was named by Hall forty years ago; if it be the same as *D. flabelliforme* or *D. sociale*, I for one am not disposed to take later names "made in Germany," but contend we should maintain our oldest Nova Scotian name of *D. Websteri*.

A consideration of dates shows that the Eel River fossils were reported on a year before Dr. Ami wrote his Synopsis, and it is hard to understand how their discovery influenced Dr. Ami AFTER he wrote *his* Synopsis.

Nor can we cannot accept Dr. Ami's conclusion, that the specimens of *D. Websteri* at McGill are the type specimens. Hall named it, and Dr. Webster's collection of some two dozen slabs are in the Provincial Museum at Halifax. They show cellules, etc., and, I fancy, a second species.

Any examination in criticism of the finding of Hall should be made of the large collection in the Halifax Museum, and at Wolfville, and not be restricted to the two specimens at McGill.

---

* The specimen is now in the Provincial Museum at Halifax.

VI.—Supplementary Notes on Drift Ice as a Transporting Agent.—By Walter H. Prest, *Bedford, N. S.*

(Read 10th March, 1902.)

A second visit to Labrador has largely confirmed my observations of 1900*, and convinced me that the transportation of debris by floating ice has been greatly overrated. Although again in the midst of icebergs and field-ice for over three months, I could find extremely few icebergs carrying earthy material. The field-ice, in huge pans, often several acres in extent, and 40 or 50 feet thick, seemed almost as destitute of debris as the bergs. The only drift-bearing ice was comparatively thin, usually much broken up and refrozen, and without doubt formed in shallow coast waters. Near the Straits of Belle Isle, the little remaining debris on this was nearly all marine or much mixed with marine organisms. Further north, especially in the bays, the transported material was largely of littoral origin. This difference was owing to the fact that the surf had nearly completed its cleansing process before the arrival of the ice at the Straits. Some of this debris-bearing ice, when examined closely, is found to be merely discoloured by a very fine, dust like material, probably not $\frac{1}{1000}$ part of the weight of the ice bearing it.

I had the pleasure of seeing how the harbor ice received its burden, on a shallow, sandy shore called the Strand, a short distance north of Sandwich Bay. Parts of this coast, even in the month of June, were fringed with ice near high-water mark. Over this ran rivulets carrying mud and gravel from the banks above, while the waves contributed their share of debris in the form of sand, seaweed, and shells.

One fact strongly supporting my contention of 1900, was brought the more prominently to my notice as I went north. This was the ever increasing quantity of debris on the thin ice

* See paper by the writer in *Trans. N. S. I. S.*, vol. x, pt. 3.

as I proceeded toward its source, showing that the ice drops the greater part of its burden near the northern Labrador coast. But the heavy field-ice and bergs even in the latitude of Nain, showed very few traces of impurities. Further south the remarkable cleanliness of the heavy ice was more noticeable. Along the southern 150 miles of the north-east Labrador coast, although icebergs were constantly in sight, I saw only five that carried impurities, the most of these having merely discoloured patches and bands. The pure white sides of the vast number of these ice masses gave evidence of the cleansing power of sun and surf since leaving their northern home.

I have made many enquiries concerning the presence of earth and stones on the ice in the North Atlantic. Among the men questioned was Captain Nordby, an old Norwegian mariner, now at Parrsboro, N. S.; Captains James and William McConnell, of Port Hilford, N. S., who have had life long experiences in these northern seas; and also several Newfoundland sealing captains, men who have had more experience with drift ice than any other seamen in the world. I find among them an almost unanimous opinion that the quantity of debris brought south by the bergs and field-ice is extremely small, and that the addition to the Grand Banks by these means would be hardly noticeable even in a hundred centuries.

That the Grand Banks of Newfoundland are not the immense deposits of ice-transported mud and other debris formerly supposed, I may instance the Virgin Ledges, awash at low water. The Tertiary fragments dredged up there indicate the existence of large areas of exposed rocky ledges, rather than the results of drift transportation from more northern regions. The disintegration of these rocks, no doubt, greatly assisted in the formation of outlying portions of the banks at a time when the eastern part of the American continent was much higher and more extensive than at present. The evidence seems to point to the existence there of an undulating, rocky plateau, which, like the adjacent provinces, had its morraines, kames, and other accumulations of drift, subsequently slightly added to by oceanic circulation.

In reference to erosion by drift ice—noticed in my former paper—an exact counterpart of the peculiar markings and furrows seen in Labrador is to be seen in the Mount Uniacke gold district, Nova Scotia. There, about three-quarters of a mile east of the 30-stamp mill, on several large exposures of quartzite, are seen hundreds of the curved furrows and scratches possible only with the irregular movements of storm-tossed boulders. These scratched surfaces incline slightly toward a shallow valley to the northwest, and show on that side the strongest evidences of ice action. Some of the more protected portions show evidences of earlier glacial action, the striations varying from S. 8° to S. 16° E.

In concluding these notes, I can only reiterate my opinions of a year ago:—1st, that the drift ice from the Arctic performs but an extremely infinitesimal part in the building of the accumulation known as the Banks of Newfoundland; 2nd, that these banks had their origin in Pleistocene times, and are simply glacial debris worked over by the sea; 3rd, that their terrestrial equivalents can be traced in the broad belt of morraines, kames, dunes, and other modified deposits which reach in a huge, irregular curve from Nova Scotia and the southern part of the New England States to the prairies of the Canadian Northwest.

VII.—AGRICULTURAL CREDIT.—BY JOHN DAVIDSON, PHIL. D.,

Professor of Political Economy, University of New Brunswick, Fredericton.

(Read 10th March, 1902.)

The great business of agriculture has generally shown itself conservative in character and slow to adopt innovations in the methods and organization which have been freely adopted in other industries; and the result has not infrequently been an agrarian crisis arising out of the conflict of old established ways and new ideas. Such a crisis occurs when a nation or a people is passing from a natural economy to a money economy, that is, from a condition when each farm was almost a self-sufficing unit, to a condition in which rents and wages are paid in money. At such periods there has usually been a good deal of distress. To a smaller degree the same difficulties arise with every extension of the market and every improvement of transportation which separates producer and consumer, and brings in a greater competition. The farmers of Europe have, during the last half century, been experiencing such difficulties; and apparently the farmers in the newest countries, whether in America or in the antipodes, have found that their enterprise in forcing an entrance into the European market has made a decisive change in their own conditions. Briefly speaking, the change is that farming has become a business requiring all the aids and assistance that modern businesses require. The days of the self-sufficing farmer have gone, never to return. Men will never again carve out homes for themselves in the wilderness. It is not that the men of to-day have not the grit and the energy and the perseverance of the heroic pioneers. It is simply that the farmer has become a producer for a market, and that his success is measured by his achievements in that market. He no longer measures himself by the old standard. He expects to buy, not to make, much of

what he needs to use. He does not fashion his implements, "knock together" his furniture, weave his own cloth. These things he buys, and is the better for buying. Nor does he look to consume in his own household most of that which his farm produces. He has become a member of another kind of society. He is a business man perforce, and produces for a market; and access to markets on the most profitable terms is as vital to him as to any other producer.

When it began to be perceived a quarter of a century ago that farming had become a business, many people, both practical men and theorists, jumped to the conclusion that the tendency towards production on a large scale would show itself in agriculture. But time has shown that production on a large scale is not so profitable in agriculture as in manufacturing, and many of the large farms which were started have been broken up. It was claimed for the large farmer, that he would have the very great advantage of being able to command the large capital which a business which produces for a distant market, as farming had become, required. Farming under the regime of world competition could be profitable to those only who could obtain credit and take advantage of the fluctuations of the market. This, the small farmer could not do, because he had little capital and less credit. The advantage of the large farmer has not been so great; but the disadvantages of the small farmer have not been less than is thus stated. And the world over, on the continent of Europe, in the Old Country, in the United States and in Canada, and in New Zealand and Australia, there is the same cry and demand from the farmer, that he is handicapped because of the high rates of interest he has to pay to obtain the capital and the credit his business requires. His occupation has become, and is daily more and more becoming, a business that depends on markets and marketing. The farmer has to measure himself by the business standard, and his complaint is that he is not provided with the necessary requisites for so conducting his business as a business. Various devices and proposals have been put forward to assist the farmer on easier terms to the two

requisites of business, viz., capital and credit; and to the examination of some of these, and to an investigation of the relation of the Canadian farmer to our existing credit institutions, this paper is devoted. The greater part of it was presented* as a report to a committee of the New Brunswick Farmers' Congress, which had been appointed to discuss the problem of cheaper money for the farmer. It was presented after a statement by the committee of the abuses and wrongs to which the farmer has to submit. In the opinion of the writer, the committee did not make out a very strong case, although some striking instances of usurious rates of interest and of the disabilities of reputable farmers in approaching a bank, were given. The negative character of the conclusions drawn in the report was thus, in a measure, justified by the failure of the committee to make out its case, and there is not, in the opinion of the writer, much room for general regret that schemes successful elsewhere are not adapted to our Canadian conditions.

The description of the difficulties in the way of the farmer obtaining the credit the modern conditions of his business demands, which has been given by Mr. Hubbard, naturally raises the question why it is that the farmer has not shared, to the full, the benefits which a developed banking system has conferred on other industries. Is there any reason in the nature of things, or has it been simply an accident, that the banks have not served the farmer as they serve the merchant or the manufacturer? Credit is just as necessary in agriculture as in commerce and industry, and it is therefore necessary to enquire whether agriculture and commerce, for instance, are so different in character that the credit they require cannot be provided by one institution. Only after coming to the conclusion that our present banking system is not suited to provide agricultural credit, as it provides commercial credit, need we take the trouble to consider remedies adopted in other countries to deal with a similar situation.

Broadly speaking, there is a marked difference. Returns in agriculture are slower than returns in trade and industry. The

* 28th January, 1902.

latter require, or should require, loans for short periods only; the former needs advances for long periods which, however, and unfortunately, are too long for lending and too short for investment, if such investment were permitted by our banking laws. Generally speaking, capital is not turned over in agriculture in a period much short of a twelvemonth, and should the season prove unfavourable, and the crop fail, credit may be required for still longer periods than a twelvemonth. It is a maxim of good banking and good business that loans should be repaid, after earning a profit for the borrower, out of the property in which the loan has been invested.

When a bank lends to a merchant, it lends on the security of a stock of finished and marketable commodities, which both merchant and manufacturer have, using their knowledge of market conditions, considered to be marketable, the manufacturer because he produced these commodities to sell them, and the merchant because he bought to sell. The bank has, therefore, every reason to be confident that the goods on which it lends will, in this case, find a market, provide a profit for the merchant, and a fund from which the loan can be repaid. The manufacturer has not, other things being equal, quite such a good standing with the banks. The bank has one judgment only guaranteeing that the goods being produced will find a market. So far as the raw material is concerned, the bank may confidently advance, because what has found a market once will find it again; but with regard to the commodities into which this raw material is to be converted, the bank has at the best the security only of the manufacturer's judgment that the goods will sell. It is true that the manufacturer has often a better standing than the merchant; but this advantage arises from the larger amount of capital invested. The small manufacturer has not, as a rule, as good a standing as the merchant using the same amount of capital. The farmer, again, has not as good a standing as the manufacturer, for the simple reason that the normal basis of agricultural credit is raw material yet to be produced; and the bank has the farmer's judgment only that the goods when

produced will find a ready market. It is true that they do find a market, for man must live on the fruits of the soil; and there is a pretty sure market for the staple agricultural products. Except on staple crops, banks lending to farmers are making speculative loans, for the market is not assured; and even with staple crops, there are greater risks in agriculture than in manufactures, owing to seasons, etc.

It is true that loans are sometimes made on other security than the property in which the loan is to be invested. The bank may lend on the basis of personal earnings from other sources, or it may lend on the security of character or of other property; but such loans are likely to be small in amount, and the ordinary type of business loan is made on the security of the property in which the loan is to be invested, and on the judgment that the product of the investment will find a ready sale. When the producer is well known in business circles, and his judgment is accepted readily regarding market conditions, the producer even of raw materials may have little difficulty in finding accommodation at the banks. The lumber operator is not, in many respects, in a much better position than the farmer. He, too, requires advances for long periods, and he, too, has, as the security he offers, a raw product on which no judgment but his own has been expressed; and his industry is to an even greater extent than the farmer's the plaything of the seasons. But the operator has little difficulty in getting the necessary advances, even from the commencement of his season's operations, and in getting larger and larger advances as his material product comes nearer to his market; for he is generally a man of capital, known in the business community and accepted as a man on whose judgment reliance can be placed. But the farmer is not a man of capital, and the banks have no confidence in his individual judgment, for they do not know him. And so the poor farmer gets none.

It is perhaps hardly necessary to say that the banks are not animated by any hostility to the farmer. The dreaded "money power" is the creation of politicians and demagogues of the

wild west. The banks are ready for any kind of business that is profitable, and does not depart radically from their methods of doing business. Agriculture requires a kind of credit they have not been in the habit of giving. The farmer asks credit for too long a period, and above all, for an uncertain and indefinite period, if it is to be of the fullest advantage to him. Moreover, the banker knows little of the individual farmer, and has but very limited opportunities for watching the business proceedings of a farmer who borrows; and the ordinary process of everyday business does not bring the farmer debtor under the banker's observation as it does the merchant or manufacturer who borrows. When the farmer is ready to market his crop, the bank is more ready to do business, although the business is usually done by middlemen; but as a producer, as a farmer pure and simple, he has not, and in the nature of things cannot expect to have, the same credit facilities as the merchant. What may be the case when the government does fully what in Australasia and to a much less extent in Canada, governments are beginning to do, viz., to guarantee a market for the farmer's produce, and even to advance the price, or part of the price, is another question. In such cases the banks ought to be willing to treat the farmer on the most favourable terms; bnt in such a case the farmer is likely, having cash in hand, to be comparatively independent of bank advances. But till that time the farmer has not much to look for from the banks. It is true, as the Hon. Mr. Blake has asserted (Hansard, 1890, p. 4295) that,

"The moment a farmer can show that he can give the same prospect of a return, with the same advantage, with the same security that other competitors for the stock of available money can give, he will get all the money he wants; and to the extent he cannot show *that* he will never get it."

But it must be remembered that the difficulty lies in the nature of the business, not in the honesty of the borrower. The problem of agricultural credit is not the problem how to supply money at low rates of interest to those who do not deserve to get it and do not know how to use it. That is likely to remain

a problem, but it is not of any interest to the community. The problem of agricultural credit is how to supply money at low rates of interest to those who are competent to manage it, so as to make it yield enough to repay the loan with a profit to the borrower. For it must always be remembered in this connection that what the lender wants is interest, not farms; and when, owing to incompetence on the part of the borrower, the lender runs a risk of getting a farm instead of his principai and interest, he will insist on being paid for the risk he runs. The farm may be just as good, but the lender does not want it, and does not care for the risk of having it left on his hands. Lending money is a matter of business, and a bank exists chiefly for this purpose; but the borrower must show that he has a legitimate use for the loan, and that he is competent to use it so as to provide for repayment at maturity. As business is, the farmer cannot satisfy these commercial requirements; and the problem for which a solution is sought is how the farmer can obtain the credit his business requires.

Is is desirable, in order to promote an understanding of the situation, that we should distinguish carefully between the general and the special advantages which arise from an efficient banking system. Our banking system is designed primarily as an agent of commerce and of industry, but it confers great and undoubted benefits upon the whole community. It provides a sound and elastic money; it gives facilities to the investor and the depositor, and by affording real services to the merchant and the manufacturer, it promotes the interests of every member of the community. Fortunnately it is not true that one man's gain is another man's loss, and we all reap some advantage, directly or indirectly, from the prosperity of our neighbours. Whatever general benefit a good banking system confers on the community at large, that the farmer shares with all his fellow citizens, and in our own case these benefits are large.

The farmer also has his share in the personal credit which the banks give, and this for him and for others under stress of competition may be of considerable amount. But this is not

really legitimate credit. It is consumer's, not producer's credit; it is accommodation which is intended to cover expenditure already made, credit which is not intended to yield a profit. It is not a credit of which a man may be proud, and it hurts or ought to hurt the standing of a man to be known to receive it. This kind of credit the farmer may receive; but it is precisely this fact that requires a remedy. He, a producer, should be entitled to legitimate or producer's credit, and should not be held down to that which non-producers, in an overdeveloped banking practice, may be given. The farmer's just ground of complaint is that, while he may share with the general public in the general benefits which a banking system confers, he is debarred, from one reason or another, from a perfectly legitimate producer's credit as a matter of business, although he may receive a limited amount of personal credit as accommodation.

Our banking system is not specially adapted to the needs of the farmer as farmer. In so far as agriculture is a branch of commerce, that is, in so far as the farmer has finished goods to sell, he may be specially benefitted. He is then in almost as good a position as the manufacturer, who, too, like the farmer, markets his wares at second hand; and the whole process of exchange is facilitated by sound banking as much for the wheat from the farm as for the cloth from the factory. For commerce we have a most excellent system, eminently well fitted to assist in marketing goods of all kinds. It provides us with an elastic currency which makes money easy at the time when most business is to be done. It facilitates the moving of the crops in the latter end of the year, and it is doubtful if the farming community realizes how much it benefits in this way, and how much harder the case would be if our bankiug system was less perfect than it is. In a general way, there is a recognition of its excellence, because the banks have served the community so well that we have heard but the faintest echoes of a "silver question" in Canada.

But we have to consider the farmer, not merely as having something to sell, but, in his more important aspect, as a pro-

ducer. Like the manufacturer, the farmer benefits when he has to market his produce, but, unlike the manufacturer, he receives little or no assistance from the banks to assist him in production; and it is precisely here that the pinch comes. Our banking system provides no credit facilities for the farmer as producer. Where, in other countries, farming is carried on on a large scale, and where the farmer is as well-known in the business world as the manufacturer using the same capital, the question of agricultural credit does not specifically arise; and if all farmers were farmers on a large scale, like the typical tenant-farmer of Great Britain, who, because he operates with a comparatively large capital and is well-known, can command credit, like any other producer, on tolerably easy terms, we could trust the farmer to get what credit his standing warranted. But large tenant-farming is not common with us, and the farmer who is in a moderate or small way of business is not known in the business world, and does not obtain the credit he requires from the banks on anything like as easy terms as the small manufacturer or tradesman, or retail shopkeeper. Wherever agriculture is followed as a business, pure and simple, little difficulty has been found in granting the farmer the necessary credit for his business; and as agriculture is coming to be pursued more and more as a business, with the market in constant view, it is possible that the farmer in the future may get more special benefit from our banking system.

Even as it is, the Canadian banks do more for the farmer than any other banking system does. Some eulogists of our banking system have applied the term agricultural to it, and this, at least, is true, that if ever a commercial banking system was entitled to the term agricultural our national system is. It is significant that where it is proposed to amend the banking system of the United States so as to afford better credit facilities for the farmer, the proposal takes the form of a system of branch banks such as we have in Canada. The only system which can compare with our own in this respect is the Scottish, where the famous "cash credits" had an enormous influence in developing

the industry and the agriculture of the country. One writer says enthusiastically :—" In the space of a hundred and fifty years it raised its country from the lowest state of barbarism to its present proud position," and "the far-famed agriculture of the Lothians, the manufactures of Glasgow and Paisley, the unrivalled steamships of the Clyde, are its proper children." This, as applied to agriculture, is no exaggeration, and it is not a little significant that the founders of the agricultural banks on the continent of Europe, to which reference will be made later, adopted from the Scottish Cash Credit System the idea of personal responsibility, which was its essence. We have not now the cash credit system in Canada, It was tried in the early days and had definitely to be abandoned because it was not suited to a country where the population was as migratory as it is with us. But the system of overdraft is quite as useful, and our banks are able to maintain the essential benefits of the cash credit system which did so much for agriculture in Scotland.

Our banks to-day do more for the farmer than the Scottish banks can now do. In Scotland itself, the cash credit as applied to agriculture is a thing of the past, and has been little used for half a century. The cash credit was partly, at least, a device for increasing the note circulation of the bank. An extra risk was taken on the loan to secure an extra profit on the notes which were thus got into circulation. When the right of issuing notes at discretion, secured only by the general assets of the bank, was withdrawn in 1845, the banks no longer had any motive for encouraging borrowers in this way, and the cash credit system was gradually withdrawn from agriculture and confined in a restricted way to commerce and industry. And it must be remembered that the farmers of the Lothians were already men of some financial standing, and that the benefits of the cash credit were never experienced by the small farmer and crofter of the north. Our Canadian banks, however, still practically retain the right and privilege of note issues at the discretion of the bank, and they are thus able to extend credit facilities to districts which would otherwise go unserved. They still have

the motive of seeking an extra profit on their note issues to induce them to take some risk on their loans. The Canadian public and the Canadian farmer are, when all is taken into consideration, the scattered population and the imperfect means of communication in particular, better served by the banks than the Scottish public and the Scottish farmer. The Scottish banks are praised because they assisted the farmer, and it was the peculiar feature of the Scottish system that suggested the European Popular Banks. The Canadian bank is in most respects like the Scottish, and has done even more for the farmer.

Our banking system is, like the Scottish, a system of branch banks, and the number of the branches is continuously increasing. By this means the banks are adapted to local needs, and it is their policy to extend their services to the remotest districts. In the eighties of last century there was considerable agitation which found expression in parliament, for a system of farmers' banks, and since that time the banks, having apparently become conscious of the danger in which the system was if more attention was not paid to the agricultural districts, have steadily increased the number of their branches. In 1881 there were 287 branches in Canada; in 1890 this number had increased to 444; and in 1900 there were 641, of which a large number are in purely agricultural districts. These branches are distributed all over the Dominion, and if the Canadian farmer has not all the banking facilities he ought to have, the reason is not here, whatever may be the case in other countries, that the bank is not at his door.

An attempt is sometimes made to show that our banking system confers a special benefit upon the farmer because it is calculated to equalize the bank rate all over the country, but that, at the best, is a blessing for which the farmer in the west has more reason to be thankful than the farmer in the east.

It is said that our system gathers up the surplus money of one district and uses it elsewhere where money is scarce; but the New Brunswick farmer who borrows is not likely to regard this as an advantage. For if the rate of interest is equalized all

over the Dominion, some districts must be made to pay more that others may pay less. If the surplus savings of the east are sent to the west, it is the western borrower and the eastern depositor who gain; the eastern borrower has to pay a higher rate of interest. Broadly speaking, the eastern, and particularly the maritime, provinces save more than the banks find local investment for at seven per cent. There are no figures published to show the relative discounts and deposits in the 105 banks and branches in the maritime provinces, but the Upper Canadian banks which are coming down here are seeking deposits, and the maritime banks which are seeking openings in the west are seeking a better outlet for their deposits. The Savings Bank returns are evidence, at least, of the relative instinct of saving in the different provinces. New Brunswick has $27.35 deposited per head of population; P. E. Island, $19.25; Nova Scotia, $17.78; Manitoba has $5.41; N. W. Territories, $1.79. I do not desire to be guilty of sectionalism in any shape or form, and that is one of the prevailing political vices of the maritime provinces; but it is not difficult to see that the Canadian banking system does not work quite so much for the benefit of the maritime borrower as it does elsewhere. For the business man the slight disadvantage of slightly dearer money is more than made up to him by the advantages of membership in a great banking system; but for the farmer there is not the same compensation.

The great merit that is claimed for People's Banks in the continent of Europe is that they fix savings in the locality in which they are made. It is there felt as a grievance in the country districts that the savings of the people are drawn to the great money centres and help there to build up the towns at the expense of the country, and accelerate the drift of population to the cities. That does not happen with us; but we have our own difficulty. The savings of the east are taken for the development of the west, and this has been regarded by some who professed to speak for the agricultural interests as an evil to be remedied. During the eighties of last century several motions to introduce bills to adapt the banking system of the Dominion to the needs of the farmer were debated, and it was

then repeatedly urged that "a measure which would provide facilities for the establishment of local banks . . . would confer a great benefit." (Can. Hansard, 1885, p. 119.) And the advantage was supposed to be that savings would by this means be fixed in their own localities, to the great benefit of borrowers, at least in such provinces as New Brunswick, which saves more than it can lend. Whether this difficulty can be overcome is another question. It is not overcome by any European system, for People's Banks were devised to provide a remedy for this evil. Nor is it overcome under the highly decentralized system of the United States. The Canadian banking system is not an agricultural system, and perhaps never has been any more fitted to supply agricultural credit than it is to-day; but it is a better system, even for the farmer, than any other that has been devised as an ordinary banking system. As a matter of fact, fixing local savings, which seems so desirable to the borrower who resides in a district that saves more than it invests, is not realisable under modern business conditions. Sooner or later, economically or otherwise, surplus savings will find their way to the district where there is demand for them. The distant borrower may be made to pay more, but the money cannot be kept at home.

There have been various proposals to amend our own and other banking systems in the interests of the farmers. So far as the Dominion is concerned, these proposals have been either to adopt the Dominion system of local banks or to establish land banks—neither of which promises any relief. The small local bank is not forbidden by our Canadian banking act, though new banks with less than $500,000 cannot now be established with rights of issuing paper money. Such local banks do continue to exist, and chiefly in the maritime provinces. Of fourteen banks with a paid up capital of less than a million, ten are in the maritime provinces. None of the New Brunswick banks has an authorized capital of more than $500,000, and the average is only $293,000; one of these, the People's Bank, the smallest in the Dominion. Yet these small banks do not serve to fix savings

in their own localities. All of them have large deposits with other banks in Canada and elsewhere; and it is the Farmers' Congress of New Brunswick, the home of the small bank in the Canadian system, that calls for this report on Agricultural Credit.

The proposals to establish land banks are generally characterized by an entire absence of knowledge of banking conditions and of the history of credit institutions. If any principle has been established by bitter experience it is that land is not a satisfactory basis for a bank. One agitator declared in the House of Commons (Hansard, 1884, p. 213,) that money based on the landed property of a country is perfectly safe, whereas experience has shown again and again that money might as well be issued based on the rings of Saturn. To attempt to modify our banking system in this way would destroy all its present value, which is, however, commercial rather than agricultural. And the problem before us is not how to destroy the credit which the merchant and the manufacturer enjoy, but how to make that credit, or some credit, available for the farmer. In my opinion, the Canadian banking system is doing all it can do, and one might even venture the assertion that it is sometimes doing, by "liberal banking" in this province and elsewhere, and by undue concession of purely personal accommodation, more than it is safe for banks to do. For the farmer, as a seller of produce, it does and can do much; for the farmer, as a member of the general public, it does and can do much; for the farmer, as a farmer, it can do but little; and it is strictly forbidden by law to attempt more than it does do. The banks are forbidden to lend on mortgage or the security of land. They may, and do, to a large extent, I believe, evade this prohibition by making land the basis on which personal accommodation is given. But the prohibition stands. Further, the wording of the act was amended so as to stand in the way of the bank making advances to a farmer as a "producer." This was done professedly to protect the interests of the farmer. It was pointed out that the general credit of the farmer "with merchants and others rests on the visible possession of certain personal property, such

chattels as grain, cattle and implements. An assignment of these, according to the form prescribed by the act, would not, like a chattel mortgage, become notorious, and the basis of a farmer's credit would be badly impaired, no creditor being able to know whether the ownership of property is in the person whom he is asked to trust or in some bank." (Breckenridge, p. 348.) The principles of our banking system are so well established and its practice so well approved by experience, that the farmer has nothing more to hope for in that quarter. He has still less to hope for from any tinkering and amendment of that system which might destroy its present perfect adaptation to our commercial and currency needs without being able to improve the farmer's position in the slightest degree.

But the problem still remains how the farmer is to be accommodated with the capital and the credit his business require. We may acquiesce in the political wisdom of rigidly confining the banks to their proper function of providing commercial credit, but must we acquiesce in the absence of credit facilities for the farmer? Agriculture is in all countries the most important, and in most the dominant, industry, and its progress cannot be hampered and hindered without national loss. We may ask, therefore, whether it is not possible to develope credit institutions, under government regulation, it may be, to supply this need, or whether it is possible for the government of the country to supply the lack directly. Such attempts have been made, and we now turn to a description of what has been done, and is being done, in other countries, or among ourselves, to meet the demand. There are two great methods, people's banks and government loans. Both are of comparatively recent origin, and both have the same aim of providing the farmer with what the banks have not, and, in my opinion, cannot adequately provide.

The People's Banks of Europe were established to provide farming credit, and it is difficult to realise the amount of business that is done through them. They are of two classes: one better adapted for providing credit to small merchants and producers, the other distinctively agricultural. They aim at making

the principle of self-help productive as well as provident. They are not mere savings banks instituted to encourage habits of thrift; they endeavour to supply credit to their members. This they do by one of two methods. They may issue shares of small amounts to form a capital of guarantee and then borrow on the security of this capital and lend out to their members. This first class is co-operative in character, but they often manage to combine co-operation with high dividends on shares, and the dividend earning instinct may influence their business to a greater extent than their co-operative principle. These are known as the Schulze Delitsch banks, after their founder, and are mainly industrial in character. They have not been found peculiarly well adapted to agriculture. The other type is peculiarly suited for the needs of small farmers and cultivators, and they do a very large and a very safe business. They are entirely co-operative in character, and are almost invariably managed by an unsalaried committee, and confine their operations to a very small area, such as the parish. They borrow the money they lend again to their members; but this money is not secured by any capital of guarantee. The members are jointly and severally liable to an unlimited extent for what they borrow to lend again. To put the matter in another way, they borrow on a joint note, to which every member is a party, and the money so obtained is loaned out to individual members. This unlimited liability makes members very careful about the character of those admitted or retained, as a man is careful about the character of a man whose paper he endorses. The loans are made for specfic purposes to individuals known to the committee who are able to ascertain whether the loan is applied to the purpose for which it was borrowed. As there are no expenses of management worth mentioning, the bank is able to lend to its members at a very small advance on what it pays, and every member shares in the joint credit of all, and the system has been well characterized as the capitalization of character and honesty. The system is well developed and it has not resulted in loss. Not a penny has been lost to any one in all the forty-seven years' experience of these

Raffeissen banks, as they are called. They do not lend on mortgages, but on simple acceptances, and yet their business has proved not only safe but much safer than the ordinary business of the commercial banks. It has been estimated that at least $750,000,000 is made available for the small producer, farmer and merchant, by these popular credit institutions, and the gain is not economic alone. Germany, Austria and Italy have thousands of these co-operative banks in operation.

The movement has extended to Ireland during recent years. It had to meet not only the opposition of ignorance, but the political prejudice of the mass of the people who saw in people's banks nothing but another device for killing Home Rule by kindness. The man most directly responsible for the establishment of these co-operative people's banks is Mr. Plunkett, who was defeated in the recent election by Col. Lynch of the Boer army. Yet, in spite of prejudice in Ireland, in five years since the movement was started, 75 Raffeissen banks have been established. Last year these banks loaned out $45,000, on which the loss amounted to $7, and what is more remarkable, there are no overdue accounts. One of the objections which the commercial bank has to the farmer as a borrower is that he is not punctual in his payments. In these co-operation banks, whether in Ireland or on the continent, punctuality in payment is universal. In one of the Irish banks 536 loans were made last year, and in twelve cases only was there a week's lateness in making payment. This is the more remarkable when it is remembered that these loans are made for strictly productive purposes, and that the borrowers are strictly held to their declared purpose. Loans are made for short or for long periods, though generally for three months with the privilege of renewal in full if the purpose is still approved and the borrower's character remains good.

Within the Dominion at least one attempt has been made to establish People's Banks on a co-operative basis to assist the farmer to obtain cheaper agricultural credit. British Columbia has legislation on its statute book authorizing the formation of and offering a subsidy to such agricultural credit institutions.

But so far the law is a dead letter, and the British Columbia Department of Agriculture explains the absence of interest in the scheme by the lack of the co-operative spirit. As a matter of fact the legislation seems to be of almost a pure academic character, answering to no popular demand and inspired by the instinct of revelation which leads people to suppose that an institution that has succeeeded elsewhere must be needed and do good here. British Columbia is probably the least agricultural of all our provinces, and is likely long to remain so; and British Columbia is very well supplied with what banking facilities our system can provide for the farmer. The failure is not due to the absencc of the co-operative spirit, but to the absence of any great need for co-operation All that is secured so laboriously and so painfully by co-operative production and co-operative banking in European countries, is without effort secured for us in the natural organisation of business. America has few examples of co-operative enterprises, because the spirit of co-operation is already largely embodied in our every-day business institutions, and we enjoy in Canada very largely all the benefits which co-operative banking secures in Europe without any of the inconveniences which accompany conscious co-operation. In Europe, co-operation affords scope for the latent abilities of men who have little hope of rising above the class in which they were born; in America there is a free career for the latents, and the born co-operators become independent managers of men. Briefly, the Canadian banking system may be said to do as much for the farmer as the European system of popular banks accomplishes there, and it is very doubtful whether, among men of our race, co-operative banking would accomplish any good result. Our areas are too vast, our population is too much scattered, our people too migratory and too anxious to rise to positions of command, to make co-operation a success. We have tried and abandoned the Scotch Cash Credit System as not well adapted to our needs; and as we have already noted the cash credit system originally suggested the European co-operative banks.

It must not be forgotten that there are two distinct questions involved in the use of the terms Agricultural Credit, and I do

not know which of these was in the mind of those who moved for the committee which asked me to report. There is the question, which is rapidly becoming a very important question, of credit for carrying on the business of farming, with which question I have been dealing. There is the entirely different question of loans for the improvement of property. Last fall there was a great drought on the North Shore, and farmers had to sell their cattle because of lack of fodder to carry them through the winter. Co-operative banking is designed to meet just such cases as this, and positively to enable the farmer to extend his operations wherever there is a prospect of profit. These banks are not mortgage banks, though some of them do lend on mortgage—a position which the apostles of the movement regard as illegitimate. There are in Europe, in addition to these popular banks, many institutions which exist for the purpose of lending money on mortgage for the improvement of land. These banks have more than a century of successful history, but their operations are confined to the landlord class, and do nothing for the business of farming as such. We have had similar institutions in America, and in Canada in particular, although they are here called by another name. We know them as Loan Companies and Trust Companies, which do a very large business in lending money on mortgage, particularly in the province of Ontario. These are purely private undertakings, and are not backed, as in Germany, by the explicit approval of the state. In 1899 there was real estate mortgaged to these loan companies to the value of 216 millions for loans amounting to 111 millions, or 51 per cent. of the value. These companies are said by a very competent observer, Professor Shortt of Queen's College, to provide an efficient and not very costly credit instrument for the farmer. Such institutions, however, are making loans for improvement, not for making the business of farming profitable. It is true that money is often borrowed on mortgage for other than improvement purposes, but such "calamity loans," as the United States Census of 1890 called them, are not made to promote the business of farming. "People mortgage their real estate to get married, to obtain divorces, and to pay alimony;

to pay their taxes, to pay rent, and to pay the money lender. They raise money by mortgage in order that they may travel, and that they may expend it in extravagant living; they speculate with it, and they relend it. Politicians pay their political debts by means of mortgages. Wives pay the debts of their husbands and educate them for the ministry. Men mortgage their real estate to pay their physician, their undertaker, and their lawyers, to help their friends and relatives to make good their defalcations, to educate their children, and to support their parents." (U. S. Census, 1890, Mortgage Vol., p. 279). But after all, loans for such purposes form but a small part of the whole, not 6 per cent. of the number, not 2 per cent. of the amount in the United States; and probably this proportion holds true of Canada, although we have no definite information. Most of the mortgages are incurred to effect improvements of a more or less permanent character.

Information is lacking regarding the rate of interest which is paid on mortgages in Canada. There is no doubt that it is high, although in New Brunswick, at least, the rate is falling, and corporations which have money which they must invest in first-class securities are being forced to consider whether it is worth while to invest in mortgages which now bring a grudging six per cent. only, with a prospect that five will soon be all that is obtainable. It is because the rate of interest is high that there is a demand in some quarters that the state should place its credit at the disposal of the farmers to enable them to borrow at less than the present market rate. Such a proposal is regarded with great alarm in some quarters, but there is ample and conservative precedent for it. The English Royal Commission on Agriculture, recognizing the demand for "increased outlay on improvements necessitated by changes in agriculture," recommended state loans to farmers, for which they claimed rightly that there was ample precedent in English agrarian legislation. The gist of the evidence laid before this commission brings out, according to Mr. Wolff (People's Banks, p. 54,) that "wherever in agriculture there is ample command of money for working a

farm, for manuring, feeding, cultivating, and holding over produce, just as circumstance may dictate, without stint and without limit, the effects of distress are very much mitigated;" and it was to afford such a mitigation to all, that the commission recommended a system of state loans.

In English and in Scottish land legislation to a slight extent, and in Irish legislation to a very great extent, the principle of using the state credit to improve the position of the farmer has been adopted and carried out. The chief object is one which has little meaning under Canadian conditions, but the same principle is involved in using state credit to create a class of small landowners as in using it to reduce the rate of interest on mortgages. Irish land legislation has advanced far from the tentative proposals in the Bright clauses of the Land Act of 1870. This first act proposed that the state advance two-thirds of the money required to convert the tenant into owner, to be repaid, capital and interest, in equal instalments of 5 per cent. in 35 years. The famous Land Act of 1881 incidentally made it possible to advance state money to the amouut of three-quarters of the purchase price, repayable in 49 years But the outstanding pieces of legislation are Conservative in origin. The Land Purchase Act of 1885 permitted the advance of the whole purchase money, repayable, capital and interest, with 4 per cent. interest, over 49 years. Under this act purchases were made on behalf of 13,700 Irish tenants, at a cost of about 45 million dollars, and the Irish tenant could, and did, become the owner of his farm by making, for that period, annual payments 44 per cent. less than his former rent had been. "This great boon," says Mr. Shaw Lefevre (Agrarian Tenures, p. 142,) "is due to the use of money borrowed from the state at 3 per cent. to purchase the landlord's interest on the very low terms of 17½ times the rent." Mr. Balfour's Land Purchase Act of 1891 went still further in the same direction. It involves the use of Imperial credit on a very large scale, and was distinguished by an effort to provide some security to the Imperial Government for repayment of the loans—a provision not unlike the process by which

the Dominion Government can deduct allowances from the Dominion subsidies to the provinces. And still further legislation is demanded by the Irish party.

The Irish land question stands by itself, and perhaps it were as well not to quote Irish agrarian legislation as a precedent; but there is no such objection to the precedent established in our sister colonies of New Zealand and Australia. There the principle of using state credit to assist the farmer has been carried out on a very large scale. The policy has still to stand the test of experience, and particularly the experience of hard times. At present the policy is still popular. The New Zealander, according to his eulogist, Mr. Lloyd, uses his national credit to get money in London to lend again in advances to settlers and free the farmer from the high rates of interest he is paying the private bankers. (Newest England, p. 151.) New Zealand began this policy in 1893, and since then its example has been followed by New South Wales, South Australia and Victoria. The system is described thus by Mr. Lloyd:

"The world over, one of the greatest obstacles in the way of the small farmer, and the large one, is the difficulty of getting capital. Often there is no money to be borrowed in the district where he lives, or if there is, it is in the hands of rich neighbours or banks, who know nothing but their bond and the pound of flesh. But in New Zealand the settler has only to go to the nearest post office to get into communication with a money lender who charges no commission or brokerage, and no fees, except for actual expenses, never exacts usury, offers no cut-throat mortgages for signature, will let him have any amount from as little as $125 to as much as $15,000, has never foreclosed, does not try to induce him to borrow more than he really needs; if he has no freehold, will lend on leasehold and good will and improvements, gives him thirty-seven and a half years to pay the money back, and accepts it from him in small instalments of principal with every payment of interest, so as to make it as little of a burden as can be, will allow him if he happens to have $25 to spare, to pay it in at any time to reduce

his indebtedness, and when it finds itself making a profit out of the business, instead of accumulating a fortune, gives him the benefit by reducing his rate."

New Zealand charges interest at the rate of 5 per cent., and up till 1900 had made about 7000 loans, amounting to more than ten million dollars, and it is claimed that not a cent has been lost, and that in 1900 there was not a penny of interest or principal due which had not been collected. The entrance of the government into the business of lending money, brought rates down all over the country, and not only those who borrowed from the government, but all borrowers, had the benefit of a reduction in the rate of interest of something like two per cent. One supporter of the New Zealand government claimed that "the action of the state in entering the money-market has made an average reduction of 2 per cent. on £32,000,000 of landed indebtedness, and £32,000,000 of other debts." The benefit may not have been as great as this and yet have been very great in its immediate effects.

The state advances money to the Australasian farmer at both ends. It advances money on his farm, and then lends him money on its produce and helps him to market it at the best terms. With this latter activity of the state on behalf of the farmer we are more familiar in Canada. Neither Dominion nor provincial governments have yet found it necessary or advisable to lend its credit to its farmers. Ontario is a slight exception, that province, I believe, making slight advances for purposes of drainage. But the Department of Agriculture, with all its manifold paternal activity on behalf of the farmer, has not advanced money for improvement or for cultivation—at least to the native farmer. To some classes of immigrants small advances have been made by another department. The Mennonites received a loan of nearly $100,000, which has all been repaid with interest; the early Icelandic settlements received some $30,000, which, owing to adverse circumstances in the settlement, had to be written off as a bad debt, the security being destroyed by disastrous floods; and similar small advances have been made to the Doukhobors

and to individual Galician settlers, the loans being secured by liens on the land. Beyond these, I know of no direct lending by the Canadian government.

Yet the Canadian governments, in their own way, are doing a great deal to make the business of farming profitable. The provision of cheap credit is not the sole condition of success, and many of the other conditions are provided. I need not say anything about the assistance which the government gives in establishing and maintaining creameries and cheese factories, or of the instruction how to make the best use of his opportunities offered the farmer by means of the agents of the departments. From one point of view, this assistance might be regarded as a system of technical education for farmers; from another point of view, as the *quid pro quo* given to the farmer who has borne the chief part of the burden of the attempt to build up industries by protection. These, however, are but the beginning of what the government does, and when one contemplates the vast projects upon which we, as a people, have embarked, or are likely to embark, it seems almost necessary to call caution. Practically, the agricultural departments have made it their aim to remove all obstacles in the way of finding a market. It uses its vast power and machinery to form an intelligence bureau in the interests of the farmer. It has improved the means of transportation; it has insisted on coal storage on train and steamer, and it has erected cold storage facilities in farming districts and at seaports; in some cases it insures the farmer against some of the ravages of nature; it has brought the best of all markets to his door; it buys eggs and butter and poultry from him at a fixed price, and pays over to him any surplus, and events may force it to buy the fruit crop in so far as that is intended for export; it buys oats from him on account of the imperial government, and when it succeeds in making a better bargain than anticipated with the steamship companies, hands the profit over to the farmer. And as I write, my evening paper comes to tell me that in order to encourage poultry-raising in the maritime provinces, the Dominion Department of Agriculture has decided, in the event of cold storage facilities not being forth-

coming on any steamer from St. John or Halifax to Liverpool during the year, to pay all freight charges on poultry shipped to Montreal in excess of one dollar per hundred pounds. On the other side of the Atlantic, almost equal care and anxiety is shown by the agents of the department that the produce of Canadian farms shall receive the best price and gain the best reputation that can be obtained.

It is no wonder that the president of a Farmers' Supply Association in the old country, with whom I had some correspondence in relation to this report, should declare that in the provision of facilities of all kinds the Canadian farmer is a full generation ahead of the farmer in the motherland.

But it may be asked why should the Government not go one step further and adopt the Australasian policy of assisting the farmer in producing as well as in marketing? Why not lend the credit of the state to the farmer to enable him to borrow money more cheaply to make improvements or simply to make the business of farming profitable? It is true that we need not trouble ourselves much about words, for if state lending on mortgage is socialistic, what shall we say about the manifold activities of the agricultural departments? The New Zealander has not been frightened at the word, and indeed declares that the epithet is misapplied. The essence of socialism is state ownership of the means of production, and the effect of this kind of state activity is to establish individual ownership more firmly. The New Zealander is of the opinion, according to Mr. Lloyd (Newest England, p. 375) that his action simply amounts to "the state giving its principal efforts to the stimulation, as a silent partner, wise counsellor and democratic co-operator, of the enterprise and industry of the individual." It may, moreover, be easily argued that in a democratic country, government aid is simply a highly organized form of self-help, that the people are using the machinery of the state for the ends for which it was devised, viz., the good of the citizens.

This is true. At times we may look at things in this way,

yet the usual way is to regard a government as an external benefactor who favours us, or our district, at the expense of others. It is true that it is our own money that constructs our roads and our bridges, builds our railways and executes our public work, yet when some protesting writer or some opposition candidate points this very fact out to us, we feel instantly that he is talking not of things as they are. As a matter of fact, we do not regard government aid as a highly organised form of self-help, but rather as a highly organised form of helping ourselves at the general expense. And it is not well that we should come to look too much for government aid in the management of our business. There is already too much reliance upon government and too little individual initiative. There are, for instance, too many men wasting time looking for government jobs, and too many people who think that five dollars of government money is worth ten dollars offered by any one else. There is some danger to national character in too great a reliance upon government assistance.

Nor can we regard the resources of a government as illimitable. A state can borrow cheaply because it borrows moderately and with discretion. It is true that a government may borrow at three per cent. or a little more, while the private borrower has to pay six or a little more. Why should not the government of Canada or the government of New Brunswick lend again to the farmer? For the very good reason that, if it did to any extent, it would not long be able to borrow at three per cent. and the whole community would be burdened. New Zealand's experience is not quite conclusive, because it has not continued long enough. We have had in our history some experience of lending the state's credit. The legislature of Canada passed in 1849 a guarantee act, guaranteeing the interest on railway bonds, as Manitoba is doing to-day, and the result was that the credit of the colony was quick to show the effects, and the guarantee system had to be withdrawn. New Zealand, during the first depression of trade, may have an even more disastrous experience.

Nothing need be said regarding the political aspect of the proposal, though that is the first which occurs to most people. What would be the relation between the borrower and the government about election time? Would concessions be made to partizans, in the matter of time, if the interest was not ready? It must be admitted that there is no evidence of similar discrimination in other business conducted by the government. After extensive enquiries, of Liberals regarding Conservative administration, and of Conservatives regarding Liberal administration, of the Intercolonial Railway, I have heard of one instance only of discrimination in freight rates in favour of a partizan, and that was in the shape of a tacit permission to overload a car. That is rather remarkable, and along with it we must take the fact that advances to settlers are generally repaid in full—though this is not so remarkable, for these men are not voters. Still there remains the general impression that politics would inevitably enter into the question of government loans to farmers, and politics are already so complicated that both parties would fight shy of such a measure.

To sum up:—The farmer need not look to any amendment of the banking system to provide him with cheaper credit, though possibly an improved banking practice might help him a little. The European system of agricultural credit on a co-operative basis could not be adopted in this country, and need not be, for our farmer is not as helpless and as much subject to the usurer as the continental peasant. The results of this co-operative system do not place the European on as good a footing as the Canadian farmer now has. No government will ever attempt the task of lending money to make the business of farming profitable. The action of governments in relation to agricultural credit has been confined to lending on mortgage. This is, in my opinion, not desirable in Canada, either for the Dominion or for the provinces. The safe line is to develop the present activities of the government on behalf of the farmers, for cheaper credit is only one of the conditions of success.

If we trace the farmer's activity from start to finish, we can see at a glance what is being done :

I. Agricultural education for adults at present—for the young in the immediate future; this includes lectures by experts, continuous experimentation, etc.

II. Assistance in certain kinds of production—creameries and cheese factories, etc.

III. For improvements—practically nothing. The Canadian governments do not lend on mortgage, nor is it desirable that they should. But something might readily be done to cheapen law costs and to facilitate the transfer of lands ; perhaps, also, to encourage local agricultural societies to form themselves into local co-operative mortgage banks, borrowing on mortgage bonds to lend on mortgage.

IV. For the provision of credit to carry on the business of farming, the government does nothing and can do nothing, though here, again, it might encourage the agricultural societies to greater practical usefulness as co-operative supply associations.

V. Markets. This has been assumed by the government in so far as export is concerned ; and since the government advances the price, it may thus assist the farmer more than by providing cheaper credit. With a practical government guarantee of a market, indeed, the banks might safely advance to the farmer almost as fully as they do to the lumber operator and the manufacturer ; and if this were to prove the case, the demand for cheaper money for the farmer would no longer be heard.

VIII.—Phenological Observations in Nova Scotia and Canada, 1901.—By A. H. MacKay, LL. D.

(*Received for Publication May, 1902.*)

I present herewith a summary of the phenological observations made in about 450 of the public schools of the Province of Nova Scotia, each county being represented by a greater cr less proportion of observers.

The observations were for the most part made by the pupils of the schools under the supervision and direction of the teachers who are responsible for their accuracy. The observers are specially directed to the determination of two dates (phenochrons)—one for the *first* appearance of the event (leafing, flowering, ripening of fruit, etc.), the other for the date when it may be said to be "becoming common." As pupils radiate from the school-house, in rural districts especially, to a distance of one or even two miles daily, and as the monotony of the walk home and back again to school next morning is very much lightened by the eager lookout for the first appearance of each phenomenon during the procession of the season, (which, when reported to the teacher and demonstrated by the presentation of the specimen, is recorded to the credit of the observer), these observations must be much more accurate than those made by a single observer, especially if he can only go out into the fields or the woods at intervals of sometimes several days. In fact, while it must be acknowledged from the investigation of the schedules that mistakes are sometimes made in noting the first date, or mistaking the species of the plant, and even in recording a correct observation, the general agreement of many school sections proves that the phenomena are most promptly noticed and correctly reported.

These 450 schedules (the best of a larger list sent in) were divided between four of the leading botanists of the Province

for the purpose of their detailed study and compilation to find average dates (phenochrons) of occurrence in each meteorological district, of which there are twelve defined in Nova Scotia. A summary of the reports of this staff—consisting of C. B. Robinson, B. A., of the Pictou Academy, Principal E. J. Lay of the Amherst Academy, Principal B. McKittrick of the Lunenburg, and Miss Antoinette Forbes, B. A., of the Windsor Academy—was published in the *Journal of Education*, April, 1902. The reports pointed out some of the errors likely to be made by observers, and suggested improvements on the schedule, which have already been adopted. They also summed up the observations so as to show the general phenochron for each object in the shore or coast belt, the low inland belt, and the highland belt of each county and of each region, some of which contain portions of several counties. These phenochrons would be very interesting to the numerous localities throughout the whole Province, but they are too voluminous for publication. They were still further generalized, so as to give the phenochrons for each region, by Mr. G. M. J. MacKay. This table is presented on pages 492 to 495.

The table of observations throughout Canada, made under the auspices of the Botanical Club of Canada by individual observers who made only the first series of observations, is also presented here, pages 497 to 501, as in the report of the Botanical Club to the Royal Society of Canada. This is done, first, to keep the series of Canadian observations uninterrupted in our transactions; secondly, for the purpose of instituting comparisons, and, thirdly, for the purpose of showing the greater fullness and accuracy of the observations as conducted in the public schools.

Then, again, it must be considered that by far the greatest value of the Nova Scotian plan appears to be the stimulation of the pupils of the public schools to observe and record, and eventually to compare. It is found to be a great aid to the teacher in interesting the pupils in many departments of Nature study; it cultivates those powers of the mind without which

future learning is, for general purposes, of little real value, and at the same time it makes the life of the pupil on the road a healthful and happy one by the added interest of the chase.

For some years Professor Ihne of Darmstadt, Germany, has been collecting and publishing annually similar observations, covering Europe from Wales to Austria and from the Baltic to Switzerland, with nearly one hundred individual observers. The object here is the minor one of obtaining phenological data, as it is with the Botanical Club of Canada.

But within the last year the Natural History Society of British Columbia issued a similar schedule, specially adapted to the west side of the continent, which has been sent to the teachers of the public schools, in order to obtain the educational benefit for the pupils all over the country, while at the same time securing more valuable phenological data than is possible otherwise.

In Denmark the same plan is also being tried this year on the recommendation of Carl Michelsen, School Inspector, Skanderborg. M. J. Mathiassen, Mullerup, Skole pr. Slagelese, issues an admirable schedule, with very effective instructions for teachers.

The phenochrons in the tables being the means of a number of dates, as a rule contain fractions, which for the sake of compactness, as no material difference is made, are omitted.

The treatment of the thunderstorm observations in a compact form appeared to be impossible, so that they are omitted from the Nova Scotian table. They may be considered by themselves on a future occasion.

The original schedules are carefully preserved, bound up in a handsome volume,—one each year. Over five hundred observations have been sent in with some schedules. The compendiums made for each belt of each region are also thus preserved for the use of future students of weather and of the changes of climate.

As a portion of the result of the study of the schedules of the north and eastern meteorological regions, I have pleasure in

presenting also a paper on the "Early Intervale Flora of Northern Nova Scotia," by Mr. C. B. Robinson, B. A., of Pictou Academy. It will be found following the tables referred to, on pages 502 to 506.

The following are the instructions printed on the ruled blanks for the summation of the individual schedules into the sheets showing the

"REGION" OR "BELT" PHENOCHRONS.

"Each province may be divided into its main climatic slopes or regions which may be seldom coterminous with the boundaries of counties. Slopes, especially those on the coast, should be subdivided into belts, such as (*a*) the coast belt, (*b*) the low inland belt, and (*c*) the high inland belt."

"In Nova Scotia the following regions are marked out :—

No.	Regions or Slopes.	Belts.			
1.	Yarmouth and Digby Co.'s....	(*a*) Coast,	(*b*) Low Inlands,	(*c*) High Inlands.	
2.	Shelburne, Queens and Lunenburg Co.'s	"	"	"	
3.	Annapolis and Kings Co.'s....	(*a*) South Mts.,	(*b*) Annapolis Valley,	(*c*) Cornwallis Valley,	(*d*) North Mts.
4.	Hants and Colchester Co.'s..	(*a*) Coast,	(*b*) Low Inlands,	(*c*) High Inlands.	
5.	Halifax and Guysboro Co.'s..	"	"	"	
6.	Cobequid Slope (to the South).	"	"	"	
7.	Northumberland Straits Slope (to the North)	"	"	"	
8.	Richmond and Cape Breton Co's	"	"	"	
9.	Bras d'Or Slope (to South-East)	"	"	"	
10.	Inverness Slope (to Gulf, N. W.)	"	"	"	

Averaging Local Phenochrons for "Region" or "Belt" Phenochrons.

"If ten or fewer good phenological observation schedules can be selected from those belonging to any given belt, they may be averaged as indicated in the columns within. If there are not ten from each belt, then it may be better to combine two belts, or if necessary, the three belts, on the form within. In the

latter case, the average will be the "region" phenochrons. When a full sheet can be made out for each belt, the averages of the phenochrons for the three "belts" will give the phenochrons for the "region"

Blanks.

"There is a convenience in averaging the dates of the ten stations, which accounts for the ten columns for stations in the form within. When a few dates are not given, it may be fair to enter in the blanks the dates from a similar neighboring station which is not otherwise utilized for the sheet. Great care should be taken that such observations taken from a schedule not summarized should appear to be what might have been observed at the station indicated in the heading; and to indicate such a transference the date should be surrounded by a circle with the pen, which will always mean that the observation was not made in the station heading the column, but in a neighbouring one, and was taken from a supernumerary schedule."

Thunder-storms.

"These dates will be entered in their respective columns and opposite the month indicated. They will not be averaged, of course."

Accuracy.

"Care must be exercised in selecting schedules, the observations of which appear to have been carefully made, neglecting any which give reason for doubt, when selecting for summation on the form within. Great care must also be exercised in copying the figures and entering them, so that no slip may occur. Every entry should be checked. One slip may spoil the effect of all the accurate numbers entering into the summation. In like manner, great care has to be taken in adding and averaging the figures; and for this purpose every sum should be done twice in reverse order, so as to give absolute confidence in the accuracy of the work."

Remarks.

"The Compiler filling one of these blanks should keep one copy for himself while sending the other to the compiler-in-chief."

"The set of stations on the right, under "when becoming common," must be *exactly* the same as on the left, under "when first seen."

A plate of graphs showing the relation between the flowering phenochrons in each region of the province of Nova Scotia, for the dates "when first seen" and "when becoming common" is given on page 496. "When becoming common" must always be a matter of personal judgment; so that the general conformity of the five pairs of curves for the flowering of the Mayflower, Strawberry, Apple, Lilac, and Blackberry, on the said plate is very interesting.

FLOWERING AND OTHER PHENOCHRONS FOR EACH REGION OF THE PROVINCE OF NOVA SCOTIA, COMPILED FROM 450 PUBLIC SCHOOL OBSERVATION SCHEDULES.

[THE PHENOCHRONS FOR EACH REGION (WHICH ARE AVERAGES OF MANY OBSERVATIONS) HAVE THE FRACTIONS OMITTED].

YEAR ENDED JULY, 1901.

NOVA SCOTIA.

Day of the year corresponding to the last day of each month.

Jan	31	July	212
Feb	59	Aug	243
March	90	Sept	273
April	120	Oct	304
May	151	Nov	334
June	181	Dec	365

WHEN FIRST SEEN. — REGIONS.

	1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. South Cobequid Slope (S. Cumb. and Col.)	7. North Cumb., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. and Victoria)	10. Inverness Slope to Gulf	Average for Province.
1. Alnus incana, Willd	104	104	103	97	104	103	107	111	104	103	104.
2. Populus tremuloides, Michx	111	116	108	109	108	102	108	107	112	111	109.2
3. Epigæa repens, L	96	101	102	94	106	106	108	110	111	109	104.3
4. Viola cucullata, Gray	115	124	121	118	123	118	123	127	126	120	121.5
5. V. blanda, Willd	113	118	118	114	117	114	119	125	120	119	117.7
6. Acer rubrum, L	117	119	116	112	121	112	122	124	122	119	118 4
7. Houstonia cærulea, L	142	131	141	135	133	121	138	141	....	123	134.
8. Equisetum arvense, L	124	124	122	127	130	127	128	136	133	115	126 6
9. Taraxacum officinale, Weber	116	127	123	120	126	122	125	129	123	122	123.3
10. Erythronium Amer. Ker	139	154	....	143	128	124	125	120	108	....	130 1
11. Hepatica triloba, Chaix	130	118	151	132	...	...	122	...	123	....	129.3
12. Coptis trifolia, Salisb	121	128	125	130	129	128	132	130	133	133	128 9
13. Fragaria Virginia, Mill	111	121	113	115	120	114	118	126	122	117	117 7
14. " " (fruit ripe)	114	160	155	156	161	153	154	165	161	161	154 0
15. Prunus Pennsyl., L	136	142	134	138	142	137	139	146	142	142	139.8
16. " " (fruit ripe)	224	185	181	....	....	....	207	....	227	....	204 8
17. Vaccinium Penn., Lam	128	135	136	137	140	137	141	146	145	143	138 8
18. " " (fruit ripe)	182	182	183	179	188	182	194	236	223	...	196 3
19. Ranunculus acris, L	136	146	135	145	149	138	142	155	151	148	144.5

WHEN BECOMING COMMON. — REGIONS.

	Average for Province	1. Yarmouth and Digby.	2. Shelburne, Queens, and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. South Cobequid Slope (S. Cumb. and Col.)	7. North Cumb., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. and Victoria)	10. Inverness Slope to Gulf.
1. Alnus incana, Willd	110.5	110	112	113	102	110	105	113	117	113	110
2. Populus tremuloides, Michx	116	118	122	113	111	....	108	118	119	121	113
3. Epigæa repens, L	112 9	106	113	109	108	112	113	116	120	119	113
4. Viola cucullata, Gray	128.4	124	131	129	124	131	123	130	[illegible]	133	126
5. V. blanda, Willd	125 5	120	127	125	124	126	121	127	131	128	126
6. Acer rubrum, L	125.8	122	128	122	118	129	122	128	133	127	129
7. Houstonia cærulea, L	140 2	149	138	144	139	143	129	146	144	....	130
8. Equisetum arvense, L	131 9	130	133	130	134	135	127	136	139	139	116
9. Taraxacum officinale, Weber	131.4	127	134	131	129	133	129	133	136	131	131
10. Erythronium Amer. Ker	143.5	164	161	....	148	157	132	130	129	127	....
11. Hepatica triloba, Chaix	135.3	144	116	155	140	....	....	127	....	130	....
12. Coptis trifolia, Salisb	135.1	128	134	133	135	135	136	136	136	139	139
13. Fragaria Virginia, Mill	128.9	124	132	126	128	132	128	130	134	131	124
14. " " (fruit ripe)	169.9	168	173	166	166	172	166	171	177	170	170
15. Prunus Pennsyl., L	145 1	140	147	138	141	148	144	144	154	148	147
16. " " (fruit ripe)	213 3	210	...	185	....	....	....	224	....	234	....
17. Vaccinium Penn., Lam	145.5	137	143	141	146	144	142	146	154	152	150
18. " " (fruit ripe)	215.	194	196	....	....	....	....	202	248	235	....
19. Ranunculus acris, L	153.7	151	155	149	152	159	152	150	162	156	151

146	155	150	155	153	129	151	159	155	141	149.4	20. R. repens, L.	157.0	157	161	159	159	163	140	156	163	159	158
142	148	141	143	143	145	150	153	157	141	146 3	21. Clintonia boralis, Raf.	151.6	146	153	146	145	153	151	156	154	161	151
139	144	134	138	144	138	141	...	140	148	140.7	22. Triillium erythrocarpum, Michx	146 4	146	150	143	142	149	142	145	....	148	153
133	142	125	140	145	139	145	155	145	142	141.1	23. Trientalis Ameri., Pursh	147.5	139	148	142	144	152	142	150	160	148	150
146	152	151	149	153	160	153	156	159	144	152.3	24. Cypripedium acaule, Ait.	157.8	153	159	149	151	163	163	158	163	167	152
143	150	157	157	156	....	148	159	145	..	151.9	25. Calla palustris, L.	159.4	162	158	160	162	162	....	151	165	155	....
131	137	133	134	138	135	137	142	142	141	137.0	26. Amelanchier Canadensis, T. & G.	142.2	137	144	137	140	144	139	141	147	146	147
200	182	192	180	181	...	204	...	194	...	190.5	27. " " (fruit ripe)	200.2	187	196	208	182	....	....	219	....	209	....
149	156	146	159	158	146	160	165	158	165	156.2	28. Rubus strigosus, Michx	162 9	153	162	153	161	168	150	166	174	169	173
188	188	175	181	....	...	187	227	211	....	193 9	29. " " (fruit ripe	206.0	200	199	182	216	....	....	193	232	220	....
161	163	162	158	166	168	164	173	173	166	165 4	30. Rubus villosus, Ait.	171 9	167	169	165	162	171	177	173	183	179	173
196	229	225	228	232	....	242	....	228	...	225 7	31. " " (fruit ripe	238 7	223	238	243	241	....	....	250	....	237	....
142	147	139	142	....	....	156	159	164	...	149.9	32. Kalmia glauca, Ait.	200 0	150	152	145	145	....	....	165	163	170	....
141	160	142	148	....	....	169	184	173	....	159 6	33. K. angustifolia L.	164.9	150	165	151	151	....	....	175	184	178	....
137	144	140	139	143	138	143	149	146	144	142 3	34. Cornus Canadensis, L.	148.9	143	151	146	149	149	144	149	157	151	150
183	205	181	180	180	....	195	...	211	....	190 7	35. " " (fruit ripe	213 3	211	208	(254)	186	...	....	203	....	218	....
152	155	149	148	156	155	156	163	161	157	155 2	36. Sisyrinchium angustifolium	160 4	157	160	156	156	162	159	161	168	165	160
157	158	155	155	161	161	157	171	160	160	159 5	37. Linnæa borealis, L.	164 7	162	164	159	160	166	166	163	174	164	169
172	172	168	184	178	...	175	...	159	182	173.7	38. Linaria Canadensis, Dum	179 3	178	177	175	188	....	....	180	....	165	192
171	167	171	156	172	169	168	170	167	169	168.	39. Rhinanthus Crista-galli, L.	174 0	173	173	176	160	177	171	175	178	175	182
160	163	165	160	163	....	167	171	179	....	166	40. Sarracenia purpurea, L	171 5	162	170	170	171	167	....	171	177	184	....
169	169	170	163	171	168	170	177	172	....	169.9	41. Brunella vulgaris, L.	172.8	165	174	169	167	....	172	176	180	179	....
176	169	185	156	....	...	188	...	185	190	178 4	42. Epilobium angustifolium, L.	181.6	170	165	...	163	....	....	191	196	194	192
173	176	172	174	176	171	174	186	184	190	177.6	43. Rosa lucida, Ehrh.	181.8	180	183	177	179	180	176	178	183	191	191
166	172	176	134	....	....	173	....	....	190	168 5	44. Hypericum perforatum, L.	172 5	172	177	178	140	....	....	176	....	....	192
162	164	163	165	185	166	168	182	172	159	168.6	45. Leontodon autumnale, L.	178.4	169	171	187	177	195	173	170	....	185	....
135	144	133	138	147	144	143	157	151	144	143.6	46. Prunus Cerasus (cultiv.)	150 4	141	151	141	144	155	152	149	164	156	151
188	189	181	188	....	....	196	....	195	...	189.5	47. " " (fruit ripe)	203 7	208	210	188	210	....	....	208	...	198	....
156	157	149	149	154	152	152	161	....	154	153.8	48. Cratægus Oxyacantha, L.	160 4	162	161	150	158	....	155	157	166	....	164
154	156	155	145	154	....	155	....	156	156	153.9	49. C. coccinea, L	160.5	162	159	162	160	161	....	159	...	162	159
136	145	138	142	148	145	145	159	146	144	144 8	50. Prunus domestica (cult'd)	150.0	144	152	142	147	152	150	150	163	150	150
139	148	139	142	150	146	145	156	149	148	146.2	51. Pryus malus (cult'd) early	152 1	148	155	144	149	156	150	150	162	155	152
150	156	148	143	161	148	153	168	155	157	153.9	52. " " late	159.7	159	161	151	154	167	153	158	170	159	165
134	141	133	133	142	135	139	147	134	147	138.5	53. Ribes rubrum (cultivated)	144.2	139	147	141	140	148	140	144	151	141	151
183	188	177	167	180	....	187	208	213	....	187.9	54. " (fruit ripe)	197.0	193	196	184	156	....	184	206	237	220	....
137	145	138	139	143	134	140	149	137	149	141.1	55. R. nigrum (cultivated)	147 0	145	151	143	142	150	143	145	155	144	152
196	200	161	194	....	....	197	....	219	....	194 5	56. " (fruit ripe)	216 3	218	223	214	204	....	...	211	....	228	....
150	157	148	149	159	153	153	165	161	156	165.0	57. Syringa vul., L. (cultivated)	160.7	154	161	154	155	164	160	158	170	167	164
173	179	181	182	177	179	182	194	206	182	183.5	58. Solanum tuberosum, L	191.5	179	185	180	215	183	186	193	197	213	184
171	174	168	169	172	179	174	177	202	184	177.0	59. Phleum pratense, L.	181 1	178	179	176	172	168	182	179	181	206	190
150	160	149	151	159	148	153	162	163	164	155.8	60. Trifolium repens, L	164.3	162	168	158	162	167	158	162	169	169	168
144	156	146	150	155	149	154	164	161	156	153 5	61. T. pratense, L	162.3	156	164	157	156	164	163	162	170	169	162
....	193	176	....	187	....	196	....	216	....	193.6	62. Triticum vulgare, L.	194.8	....	198	180	158	....	....	209	....	229	....
180	190	187	....	....	....	199	....	207	....	192.6	63. Avena sativa, L.	209.7	....	202	....	....	....	....	212	....	215	....
....	198	183	183	....	....	196	....	212	....	194 4	64. Fagopyrum esculentum, L.	218.8	....	221	193	....	....	....	211	....	210	....
135	139	131	128	137	134	132	142	132	145	135 5	65a. Earliest full leafing of tree	....	....	....	....	....	....	....	....	....	....	....
161	161	154	154	154	147	154	159	157	169	157.0	65b. Latest " "	....	....	....	....	....	....	....	....	....	....	....

FLOWERING AND OTHER PHENOCHRONS FOR THE PROVINCE OF NOVA SCOTIA—*(Continued).*

Year ended July, 1901. Nova Scotia.

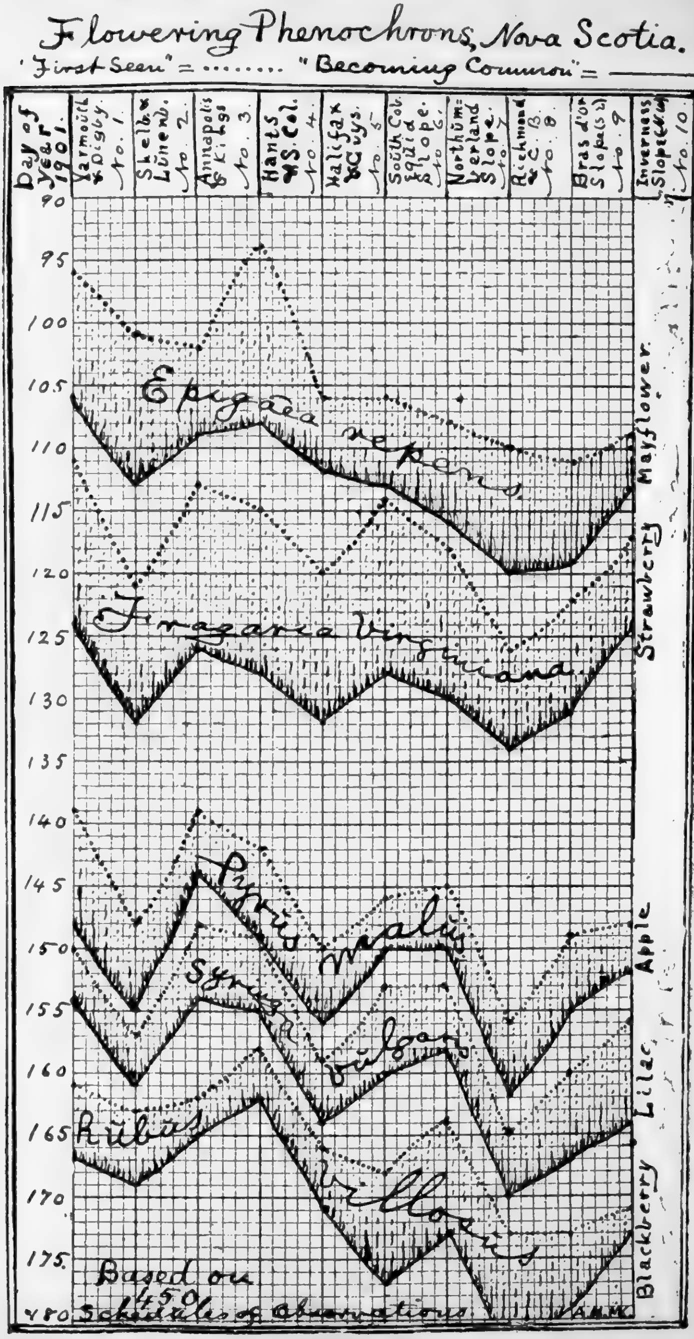
Day of the year corresponding to the last day of each month.

Jan	31	July	212
Feb	59	Aug.	243
March	90	Sept	273
April	120	Oct.	204
May	151	Nov	334
June	181	Dec.	365

When First Seen. Regions. 1. Yarmouth and Digby.	2. Shelburne, Queens, and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. South Cobequid Slope (S Cumb. and Col.)	7. North Cumb., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. and Victoria.)	10. Inverness Slope to Gulf.	Average for Province	Year ended July, 1901. Nova Scotia.	When Becoming Common. Average for Province.	Regions. 1. Yarmouth and Digby.	2. Shelburne, Queens, and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. South Cobequid Slope (S. Cumb and Col.)	7. North Cumb, Col., Pictou, and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. and Victoria.	10. Inverness Slope to Gulf.
97	110	108	110	113	108	116	110	115	101	108.7	66. Ploughing (first of season)	118.8	109	121	119	....	....	114	127	124	126	110
109	116	116	117	122	116	124	126	127	119	119 2	67. Sowing "	129.1	121	127	126	....	....	124	135	137	134	129
108	115	121	123	120	118	126	117	122	118	118.8	68. Potato-planting "	129.6	118	128	136	....	....	140	138	126	131	120
120	124	121	134	135	128	133	121	112	101	122 9	69 Sheep-shearing "	131 3	133	133	135	....	....	133	143	135	121	117
179	184	182	185	189	191	197	203	210	201	192.1	70. Hay-cutting "	202.6	185	188	188	....	....	213	207	211	215	214
237	235	236	239	241	236	241	245	243	238	239.1	71. Grain-cutting "	249.9	244	247	247	....	....	244	252	258	257	250
257	262	259	260	268	266	272	272	277	268	266.1	72. Potato-digging "	276.9	251	273	269	....	....	288	281	281	283	289
76	86	72	80	88	79	85	73	88	83	81.0	73a. Opening of rivers "	....	....	....	....	....	....	....	....	....	....	....
88	96	96	92	104	79	97	92	107	98	94 9	73b. Opening of lakes "	....	....	....	....	....	....	....	....	....	....	....
99	103	113	119	105	108	115	103	102	113	107.9	74a. Last snow to whiten ground	....	....	....	....	....	....	....	....	....	....	....
114	114	124	113	121	120	121	108	115	110	116.0	74b. Last snow to fly in air	....	....	....	....	....	....	....	....	....	....	....
114	117	126	129	120	162	128	121	139	134	129 0	75a. Last spring frost—hard	....	....	....	....	....	....	....	....	....	....	....
142	145	150	167	159	....	154	154	156	....	153.4	75b, " " hoar	....	....	....	....	....	....	....	....	....	....	....
....	97	96	93	96	94	91	....	115	....	97 4	76a. Water in streams—high	....	....	....	....	....	....	....	....	....	....	....
176	250	225	....	212	242	199	....	215	....	217 0	76b. " " low	....	....	....	....	....	....	....	....	....	....	....
263	262	270	252	264	254	258	261	225	225	256.4	77a. First autumn frost—hoar	....	....	....	....	....	....	....	....	....	....	....
288	286	291	277	290	291	290	300	230	319	286 2	77b. " " hard	....	....	....	....	....	....	....	....	....	....	....
293	292	290	297	293	290	292	304	297	292	294.0	78a First snow to fly in air	....	....	....	....	....	....	....	....	....	....	....
310	307	307	315	312	296	302	321	300	294	306 4	78b. " whiten ground	....	....	....	....	....	....	....	....	....	....	....
349	343	342	340	347	....	337	339	353	....	343.8	79a. Closing of lakes	....	....	....	....	....	....	....	....	....	....	....
355	353	350	348	344	....	345	354	351	....	350.0	79b. " rivers	....	....	....	....	....	....	....	....	....	....	....

77	91	93	73	92	76	85	70	107	75	83.9	81a.	Wild ducks migrating, N											
312	310	305	324		310	322	314			313.9	81b.	" " S											
79	81	86	85	84	79	82	82	90	83	83.1	82a.	Wild geese migrating, N											
319	327	327	345		323	331	308			325.7	82b.	" " S											
86	90	91	88	91	97	90	99	106		92.9	83.	Melospzia fasciata, North											
77	85	83	78	82	83	88	89	91		84.4	84.	Turdus migratorius "											
61	110	87	88	101		80				84.5	85.	Junco hiemalis "											
112	134	152	138	136	137	133				134 6	86.	Actitis macularia "											
106	110	108			128	135				117.4	87.	Sturnella magna "											
131	125	136	128	134	130	127	130			130.1	88.	Ceryle Alcyon "											
130	134	134	131	155		146	111			134 4	89.	Dendrœca coronata "											
139	141	142	126	129		140	135			136 0	90	D. æstiva "											
140	[illegible]	123	118	151		110	136			127.0	91.	Zonotrichia alba "											
154	146	145	148	144	142	147	140	151		146 3	92	Trochilis colubris "											
139	142	137	139		120	137				135.7	93.	Tyrannus Carolinensis "											
130	116	113	132			139				126 0	94.	Dolychonyx oryzivorus "											
151	137	141	137	141	119	150				139 4	95.	Spinis tristis "											
123	147	136	145			144				139 4	96.	Setophaga ruticilla "											
172	173	143	139			117				148.8	97.	Ampelis cedrorum "											
142	141	126	112		129	150				133.3	98.	Chordeiles Viginianus "											
93	99	100	102	103	102	101	104	108	97	100.9	99.	First piping of frogs											
101	104	113	107	108	108	111	113	119	108	109.2	100.	First appearance of snakes											

Graphs showing the general conformability of the phenochrons on the right and left sides of the above table are shown for illustration on the next page for Nos. 3, 13, 51, 57 and 30,—the Mayflower, Strawberry, Apple Lilac, and Blackberry.


Flowering Phenochrons, Nova Scotia.
"First Seen" = ... "Becoming Common" = ——
Day of Year 1901.
Yarmouth & Digby. No. 1
Shelb. & Lunenb. No. 2
Annapolis & Kings. No. 3
Hants & S. Col. No. 4
Halifax & Guys. No. 5
South Col. Equid Slope. No. 6.
Northumberland Slope. No. 7
Richmond & C. B. No. 8
Bras d'Or Slope(s.w.) No. 9
Inverness Slope(Atlan) No. 10
90
95
100
105
110
115
120
125
130
135
140
145
150
155
160
165
170
175
180
Epigaea repens
Mayflower.
Fragaria Virginiana
Strawberry
Pyrus malus
Apple
Syringa vulgaris
Lilac
Rubus villosus
Blackberry
Based on 450 Schedules of observations
A.H.M.

List of Observers and Stations for Table of Botanical Club of Canada, 1901, on the following pages.

Nova Scotia: Four hundred and fifty School Sections.
New Brunswick: Mr. J. Vroom, St. Stephen.
Prince Edward Island: Mr. John MacSwain, Charlottetown.
Quebec: Miss A. L. Beckett, Richmond (1).
" Miss J. M. Varney, " (2)
" Miss Annie M. Dresser, Nicolet.
Ontario: Dr. James Fletcher, Ottawa (1).
" Dr. Cephas Guillet, " (2).
" Miss Alice Hollingworth, Beatrice, Muskoka.
Manitoba: Mr. B. J. Hales, Macgregor.
Assiniboia: Mr. T. H. Donnelly, Pheasant Forks.
Saskatchewan: Rev. C. W. Bryden, B. A., Willoughby.
Alberta: Mr. Percy B. Gregson, Waghorn.
British Columbia: Mr. J. K. Henry, B. A., Vancouver.

References in "Vancouver" Column of the Table Following:

a. Alnus rubra.
b. Acer macrophyllum.
c. Prunus emarginata.
d. Vaccinium myrtilloides.
e. Rubus occidentalis.
f. Rosa Nutkana.

PHENOLOGICAL OBSERVATIONS, CANADA, 1901.

(The Phenochrons for Nova Scotia are averages based on observations made at about 450 stations, and have fractions which are omitted in this table.)

YEAR, 1901.

Day of the year corresponding to the last day of each month.

Jan	31	July	212
Feb	59	Aug	243
March	90	Sept	273
April	120	Oct	304
May	151	Nov	334
June	181	Dec.	365

Number.		Average dates for Nova Scotia.	Observation Stations. St. Stephen, New Brunswick.	Charlottetown, P. E. I.	(1) Richmond, Quebec.	(2) Richmond, Quebec.	Nicolet, Quebec.	(1) Ottawa, Ontario.	(2) Ottawa, Ontario.	Muskoka, Ontario.	Macgregor, Manitoba.	Pheasant Forks, Assiniboia	Willoughby, Saskatchewan.	Waghorn, Alberta.	Vancouver,
1	Alnus incana, Willd	104	104	113	....	....	109	108	109	107	....	....	....	....	64
2	Populus tremuloides, Michx	109	....	113	....	....	...	108	108	113	....	....	....	118	...
3	Epigæa repens, L	104	....	110	141	....	110	108	....	....	....	....	....	....	...
4	Viola cucullata, Gray	121	....	....	147	142	111	...	....	123	....	135	....	....	...
5	V. blanda, Willd	117	126	....	151	153	111	....	....	123	....	139	....	....	...
6	Acer rubrum, L	118	. .	118	....	...	124	113	106	116	....	....	....	....	98
7	Houstonia cærulea, L	134	140	....	149	...	...	....	....	...	....	....	....	....	...
8	Equisetum arvense, L	126	145	....	....	....	...	107	...	138	....	....	....	....	7
9	Taraxacum officinale, Weber	123	126	132	155	....	123	114	118	121	....	143	....	....	8
10	Erythronium Amer, Ker	130	....	....	144	139	118	115	114	118	....	....	....	....	...
11	Hepatica triloba, Chaix	129	122	....	140	125	111	105	104	....	....	....	....	169	...
12	Coptis trifolia, Salisb	128	147	....	. ..	....	...	...	124	132	....	....	....	....	...
13	Fragaria Virginiana, Mill	117	132	135	141	....	112	121	99	132	...	139	....	137	...
14	" " (fruit ripe)	154	167	....	191	....	154	....	164	182	161	....	....	....	14
15	Prunus Pennsylvanicum, L	139	....	....	162	....	127	141	128	132	....	142	....	138	12
16	" (fruit ripe)	204	....	....	...	...	...	....	....	....	....	....	....	201	...
17	Vaccinium Penn., Lam	138	147	...	....	....	....	....	121	....	....	....	....	....	61
18	" (fruit ripe)	199	....	....	....	....	...	....	...	203	....	....	....	....	...
19	Ranunculus acris, L	144	161	....	172	170	147	144	143	169	....	....	. ..	147	...
20	R. repens, L	149	....	....	....	....	150	....	....	....	....	116	....	....	14
21	Clintonia borealis, Raf	146	....	....	141	....	1 7	149	143	....	....	....	....	....	...
22	Trillium erythrocarpum, Michx	140	....	....	144	140	119	129	....	...	....	....	....	....	...
23	Trientalis Ameri., Pursh	141	....	....	...	....	....	....	143	....	....	....	....	....	...
24	Cypripedium acaule, Ait	152	160	....	....	....	151	....	....	....	....	....	....	169	...
25	Calla palustris, L	151	....	....	....	....	163	117	....	148	....	....	....	....	...
26	Amelanchier Canaden., T.& G.	137	143	....	....	....	...	128	128	123	...	138	....	136	12
27	" " (fruit ripe)	190	....	....	....	....	..	....	....	....	....	....	....	198	...

PHENOLOGICAL OBSERVATIONS, CANADA, 1901.

Number.	YEAR, 1901. Day of the year corresponding to the last day of each month. Jan. ... 31, Feb. .... 59, March .. 90, April ....120, May ....151, June ....181, July ....212, Aug. ....243, Sept. ... 273, Oct ....304, Nov. ....334, Dec 365	Average dates for Nova Scotia.	Observation Stations. St. Stephen, New Brunswick.	Charlottetown, P. E. I.	(1) Richmond, Quebec.	(2) Richmond, Quebec.	Nicolet, Quebec.	(1) Ottawa, Ontario.	(2) Ottawa, Ontario.	Muskoka, Ontario.	Macgregor, Manitoba.	Pheasant Forks, Assiniboia.	Willoughby, Saskatchewan.	Waghorn, Alberta.	Vancouver, British Columbia.
8	Rubus strigosus, Michx	156					149		151					190	146e
9	" (fruit ripe)	193												201	
0	Rubus villosus, Ait	165					152								
1	" (fruit ripe)	225								235					
2	Kalmia glauca, Ait	149	162												121
3	K. angustifolia, L	159													
4	Cornus Canadensis, L	142							147				153		134
5	" (fruit ripe)	190								238					
6	Sisyrinchium angustifolium	155			177	181	153		151					137	
7	Linnæa borealis, L	159	167						170						
8	Linaria Canadensis, Dum	173			147		173								
9	Rhinanthus Crista-galli, L	168													
0	Sarracenia purpurea, L	166													
1	Brunella vulgaris, L	169								182					
2	Epilobium angustifolium, L	178								190				192	171
3	Rosa lucida Ehrh	177	189		189		152		164	193				166	148f
4	Hypericum perforatum, L	168								191					
5	Leontodon autumnale L	168								260					
6	Prunus Cerasus (cultivated)	143	147			143	128	132							107
7	" (fruit ripe)	189													167
8	Cratægus Oxyacantha, L	153													
9	C. coccinea, L	153		153	160			143	145	146		142			
0	Prunus domestica (cultivated)	144			167		129		124	129		141			104
1	Pyrus malus (cultivated) early	146	147	139	140		137	140		138					117
2	" " late	153													
3	Ribes rubrum (cultivated)	138	141			143	145			129		141			
4	" (fruit ripe)	187													
5	R. nigrum (cultivated)	141					145		136	133		139			
6	" (fruit ripe)	194													

PHENOLOGICAL OBSERVATIONS, CANADA, 1901.

YEAR, 1901.

Day of the year corresponding to the last day of each month.

Jan.	31	July	212
Feb.	59	Aug.	243
March	90	Sept.	273
April	120	Oct.	304
May	151	Nov.	334
June	181	Dec.	365

Number.	YEAR, 1901.	Average dates for Nova Scotia.	Observation Stations.											
			St. Stephen, New Brunswick.	Charlottetown, P. E. I.	(1) Richmond, Quebec.	(2) Richmond, Quebec.	Nicolet, Quebec.	(1) Ottawa, Ontario.	(2) Ottawa, Ontario.	Muskoka, Ontario.	Macgregor, Manitoba.	Pheasant Forks, Assiniboia.	Willoughby, Saskatchewan.	Waghorn, Alberta.	Vancouver, British Columbia.
57	Syringa vul., L. (cultivated)	165	....	153	150	....	140	....	133	140	....	....	....	....	12[illegible]
58	Solanum tuberosum, L.	183	...	....	....	....	161	....	....	193	....	....	..	201	16[illegible]
59	Phleum pratense, L.	177	...	....	....	....	152	....	129	193	....	....	....	205	...
60	Trifolium repens, L.	155	....	....	171	....	149	....	133	...	....	....	....	190	13[illegible]
61	T. pratense, L.	153	....	....	178	185	144	...	....	....	....	....	....	....	14[illegible]
62	Triticum vulgare, L.	193	....	....	....	....	...	....	....	....	....	....	....	202	...
63	Avena sativa, L.	192	....	....	....	....	....	....	....	....	....	....	....	206	...
64	Fagopyrum esculentum, L.	194	....	....	....	....	....	....	....	....	....	....	....	....	...
65a	Earliest full leafing of tree	135	....	....	....	....	....	....	...	....	....	..	129	....	...
65b	Latest full leafing of tree	157	....	...	....	....	...	....	....	....	....	....	....	....	...
66	Ploughing (first of season)	108	....	....	130	....	118	....	....	....	99	119	115	105	...
67	Sowing "	119	...	108	....	...	123	....	....	....	....	133	116	102	...
68	Potato-planting "	118	....	....	....	....	121	121	....	....	....	134	137	110	...
69	Sheep-shearing "	122	....	...	181	...	121	114	....	....	....	153	158	147	...
70	Hay-cutting "	192	....	....	....	....	....	....	..	...	....	237	....	193	...
71	Grain-cutting "	239	....	213	....	....	....	....	....	....	....	245	....	....	...
72	Potato-digging "	266	....	...	....	....	....	....	....	....	....	263	205	191	...
73a	Opening of rivers "	81	....	97	127	....	....	....	....	....	93	100	....	83	...
73b	Opening of lakes "	94	....	....	....	....	....	....	....	...	99	....	..	120	...
74a	Last snow to whiten ground	107	...	....	129	159	121	110	110	111	89	166	155	155	...
74b	Last snow to fly in air	116	....	....	....	179	...	....	....	111	117	....	...	156	...
75a	Last spring frost—hard	129	130	....	....	191	126	....	...	....	....	132	....	156	...
75b	" " hoar	153	145	....	....	...	....	....	....	....	126	....	157	156	1[illegible]
76a	Water in streams—high	97	....	....	...	....	....	....	....	...	94	111	....	117	...
76b	" " low	217	....	....	....	....	....	....	....	....	....	144	....	330	...
77a	First autumn frost—hoar	256	....	270	....	....	....	....	....	277	...	....	....	229	...
77b	" " hard	286	....	....	....	356	....	....	....	280	....	....	....	307	...
78	First snow to fly in air	294	....	....	....	....	...	314	....	276	....	....	....	248	...
78	First snow to whiten ground	306	....	....	....	....	313	....	314	276	....	....	259	248	...

PHENOLOGICAL OBSERVATIONS, CANADA, 1901.

YEAR, 1901.

Day of the year corresponding to the last day of each month.

Jan.	31	July	212
Feb.	59	Aug.	243
March	90	Sept.	273
April	120	Oct.	304
May	151	Nov.	334
June	181	Dec.	365

Number.	YEAR, 1901.	Average dates for Nova Scotia.	Observation Stations. St. Stephen, New Brunswick.	Charlottetown, P. E. I.	(1) Richmond, Quebec.	(2) Richmond, Quebec.	Nicolet, Quebec.	(1) Ottawa, Ontario.	(2) Ottawa, Ontario.	Muskoka, Ontario.	Macgregor, Manitoba	Pheasant Forks, Assiniboia.	Willoughby, Saskatchewan.	Waghorn, Alberta.	Vancouver, British Columbia.
79a	Closing of lakes	343	...	...	...	...	...	...	...	...	...	...	...	...	...
79b	Closing of rivers	350	...	5	...	...	...	...	...	...	...	...	...	...	...
81a	Wild ducks migrating, north	83	...	..	126	103	...	...	103	...	...	96	...	84	...
81b	" " south	313	...	...	...	...	...	...	...	...	...	...	...	...	...
82a	Wild geese migrating, north	83	...	77	125	118	..	...	112	114	...	85	...	83	...
82b	" " south	325	...	244	...	...	...	...	...	...	...	...	...	245	...
83	Melospzia fasciata, north	92	...	104	...	...	...	86	82	...	...	108	...	...	...
84	Turdus migratorius, "	84	...	99	108	100	...	88	81	...	...	99	...	88	...
85	Junco hiemalis, "	84	...	105	...	...	...	92	87	116	...	99	...	...	...
86	Actitis macularia, "	134	...	...	...	...	...	...	124	...	...	...	...	...	...
87	Sturnella magna, "	117	...	...	...	...	...	127	95	...	...	100	...	...	...
88	Ceryle Alcyon, "	130	...	...	...	...	...	...	103	...	...	...	...	...	...
89	Dendrœca coronata, "	134	...	...	...	...	...	...	130	...	...	...	...	...	...
90	D. æstiva, "	136	...	..	...	124	121	135	129	...	...	...	...	...	...
91	Zonotrichia alba, "	127	126	...	...	..	...	94	105	...	...	...	...	...	...
92	Trochilus colubris, "	146	...	...	171	115	...	128	141	138	...	...	...	...	...
93	Tyrannus Carolinensis, "	135	...	...	...	...	...	...	131	...	...	...	...	...	...
94	Dolychonyx oryzivorus, "	126	...	...	144	161	138	127	136	...	...	...	...	...	...
95	Spinis tristis, "	139	...	...	...	...	...	...	116	...	118	...	...	...	...
96	Setophaga ruticilla, "	139	...	...	...	...	...	...	136	...	...	...	...	...	...
97	Ampelis cedrorum, "	148	...	...	...	...	...	48	...	...	...	...	...	...	...
98	Chordeiles Viginianus, "	133	...	152	...	...	...	135	141	162	...	145	...	...	...
99	First piping of frogs	100	...	99	141	118	116	...	100	101	94	112	...	108	50
100	First appearance of snakes	109	132	...	162	118	118	...	103	103	96	114	111	121	...

Early Intervale Flora of Eastern Nova Scotia.—By C. B. Robinson, B. A., *Pictcu Academy.*

[Report on Phenological Schedules of Northern Nova Scotian Public Schools, 1901]

Information regarding the distribution of several of our most interesting specimens of flowering plants has been so greatly extended of late, especially through the increased attention given to this subject in the public schools, that some generalizations are becoming possible, and it will be the aim of this paper to attempt a modest beginning along these lines in the case of one society of plants, that composed of the earlier blooming species of the intervale flora of Eastern Nova Scotia.

Even in Macoun's Catalogue only two references each for the entire Province, are given to *Sanguinaria Canadensis L.*, *Bicuculla Cucullaria* (L.), Millsp., and *Erythronium Americanum*, Ker. Now, all three of these species grow abundantly, either upon the intervales themselves or still more commonly on shaded banks bordering them, in the case of each of the three rivers flowing into Pictou harbor, beginning just beyond the farthest point reached by the tide and continuing towards their head-waters as far as any observations have been made.

Nor are these exceptional cases. While no school in the Coast belt of Cumberland reported in 1901 any of these three, seven, possibly eight, in the Lowland belt record *Erythronium*, and four of these in additional observations include at least one of the others.

Of the eleven Cumberland Highland Stations sending in schedules no less than six have credible dates for *Erythronium*, though none have noted either of the others. It should be stated that while *Erythronium* is among the plants listed for observation, the others are not, so that, in view of the facts elsewhere, such negative evidence is of little, perhaps of no value.

In West Colchester four out of six Coast and three out of seven Highland Stations report *Erythronium*. In Northern Colchester (Stirling) only one Coast and no Lowland Stations

assign a date to *Erythronium*, though one of the latter notes *Bicuculla*, but in the Highlands this is changed, as four out of five report at least two and one of them all three species.

Only one Coast Section in Pictou County records any of these, but it has two, *Erythronium* and *Sanguinaria*. An interesting isolated fact may be related here. At Brown's Point, on the I. C. R., just outside Pictou, *Erythronium* grows in the open, and not one hundred yards from salt water. It is supposed to have been accidentally introduced by students bringing specimens from their homes on East or West River for class examination at the Academy.

Two Pictou Lowland Stations report *Sanguinaria*, one the others also; but nine out of fifteen Highland Sections have *Erythronium*, and six of these at least one of the others.

East of Pictou County it is very doubtful whether these species are any longer co-existent. From Antigonish the only reference to *Erythronium* is clearly an error for *Clintonia*, while beyond the Strait there is not at present any sufficient proof of its occurrence.

One of the Highland Districts of Antigonish reports *Sanguinaria* and *Bicuculla Cucullaria*, another *Sanguinaria* and *B. Canadensis* (Goldie) Millsp. The latter is very likely to have been the more common species, as this error is rather frequent. But from Richmond and Cape Breton Counties there is no mention of any of these, though four out of the five Inverness stations on the Bras d'Or Slope report *Bicuculla* and one of these *Sanguinaria* as well, and one of the two Victoria schools to send in a schedule assigns a date to *B. Canadensis.*

Finally on the Gulf Slope, the only Lowland and one of the three Coast sections report *Bicuculla*, the former *Sanguinaria* also.

These facts seem to warrant the conclusion that, with the exception noted, all three of these species are regularly found upon most of the river intervales in this district, beyond the reach of salt water. In most of the Coast and many of the Lowland districts cultivation has so far proceeded that they must

often have been exterminated; but, in addition to this, the conditions prevailing in the more hilly districts seem to favor their growth. Indeed, the more probable presence of a shaded hillside beside the stream would go far in itself to explain this.

These species have been chosen as both eminently typical and likely to have been noticed. With them would almost everywhere be found the Spring Beauty (*Claytonia Caroliniana*, Michx.), but its distribution is very much wider, as it is found in rich woods even on the summits of some of our highest hills.

Just outside the limits of shade will nearly always be found the Downy Yellow Violet, *Viola scabriuscula* (T. & G.), Schwein, which is widely reported throughout the district from Cumberland to Cape Breton. *V. rotundifolia*, Michx., is said to occur in several localities, all such, however, that the preceding species would be expected, and to it these references probably belong. *V. Labradorica*, Schrank, and *V. arenaria*, D. C., are likely found throughout the district, the latter on drier sandy soil, and apparently the commoner in Pictou Co.

Uvularia sessilifolia, L. has been noticed by a much smaller number of observers, but it is widely distributed, and probably on the whole nearly as common as the others.

To complete this list, so far as the common earlier flowers are concerned, there should be added *Ranunculus abortivus*, L., *Actaea rubra* (Ait.) Willd, and *Dentaria diphylla*, Michx., though none of these is strictly restricted to such localities. Prof. Macoun, (Catalogue, Part III., p. 480), states that his N. S. specimens of *R. abortivus* belong to *Var. Micranthus*, as then understood. Careful study of plants gathered at various points along West River, Pictou, where they are abundant, leaves no doubt that they at least should be referred to *R. abortivus*.

Panax trifolium, L is less often reported, and is certainly not found in some localities where all of the preceding are common, but its distribution is probably pretty general.

Interesting and beautiful, but rare, is *Hepatica Hepatica* (L.), Karst, not certainly known except from the East River of

Pictou and Antigonish. Equally so is *Primula Mistassinica*, Michx., found in only two places.

The Northern Inverness stations are responsible for the addition of *Caltha palustris*, L. *Anemone Americana*, L. is another contribution from this district, but blooms later.

Much more common is *Trillium cernuum*, L., but it grows also in other situations. Moreover, on the West River of Pictou there occur some unusual forms, which seem intermediate between this species and *T. erectum*. Some Antigonish references to *T. grandiflorum* may indicate a similar fact.

The trees and shrubs first to bloom in such localities are the Elm *(Ulmus Americana)*, which has everywhere been left on account of its striking beauty, and the Beaked Hazel *(Corylus rostrata.)* But still more typical, though later blooming, are the species of *Cratœgus*, which so often occur along the banks, forming in many cases almost impenetrable thickets. Until recently these have all been referred to *C. coccinea*, L., but it is now known that there are several species, at least five and probably six, including some new to science, *C. coccinea* being, however, the commonest and in the greatest numbers where found, *C. acutiloba*, the next in order of frequency, being hardly an intervale plant.

During June the intervales become covered with verdure, including most of the plants of field and roadside, whether native or introduced. But there are again some rather typical forms. Among them should first be noted *Sanicula Marilandica*, L.; *Washingtonia Claytoni* (Michx.), Britton; *W. longistylis* (Torr), Britton, (which is much commoner than usually supposed); *Geum Virginianum*, L.; *G. Canadense*, Jacq.; *Heracleum lanatum*, Michx., which seem to be found nearly everywhere. Some others call for more particular attention. *Ranunculus recurvatus*, Poir, is known from two localities on West and one on East River, Pictou County. *Thalesia uniflora* (L.), Britton, is found at nearly the same places. The former has recently been reported from Inverness.

Triosteum perfoliatum, L., occurs at Riverton, and near it is *Anemone Virginiana*, L. *Polygonatum biflorum* (Walt.), Ell., which is widely though sparingly reported, prefers the shade, as does *Juncoides pilosum* (L.), Kuntze, while on steep, stony banks *Rhus radicans* is frequent. Rough places beside the stream are almost sure to contain *Senecio obovatus*, Muhl., *S. Balsamitae*, L., and *Apocynum cannabinum*, L.; *A. androsaemifolium*, L., being even commoner, but in richer soil. With them on each of the three Pictou rivers will be seen the leaves of *Meibomia Canadensis* (L.), Kuntze, the flowers not appearing before the middle of July. It is, however, hardly too much to say that the distribution of almost all of these species is as yet insufficiently known.

Many plants found in other locations are also frequent here. Such are *Habenaria dilatata* (Pursh), Hook, *Vagnera racemosa*, L., *Myrica Gale*, L., and *Ranunculus reptans*, L., but it has not been the purpose of this paper to enumerate them.

Why this, the richest and most interesting division of our flora, should have received such scanty attention is, perhaps, a puzzle, and even yet not enough is known of the later species to make many general statements. It is, of course, a matter of common knowledge that the most characteristic plant during the middle of July is *Lilium Canadense*, L., which later gives way to *Clematis Virginiana*, L., and this in its turn to the Asters, but much more work must be done before the subject can be accurately treated.

IX.—LABRADOR PLANTS [COLLECTED BY W. H. PREST ON THE LABRADOR COAST NORTH OF HAMILTON INLET, FROM THE 25TH OF JUNE TO THE 12TH OF AUGUST, 1901.] —BY A. H. MACKAY, LL. D.

(Communicated 14th January, 1902.)

The plants which I present herewith, mounted, were collected by Mr. Walter H. Prest, of Halifax, when exploring the Labrador coast north of Hamilton Inlet last summer (1901), between the 25th of June and the 12th of August. The specimens were collected merely as flowers to be taken back as mementos of a visit to this far-off region, so that only the more striking portions of the plants, such as could be easily accommodated between the pages of a magazine, were taken. These portions were characteristic enough, however, to enable the species in nearly every case to be determined. They have also been referred to Professor John Macoun, Dominion Botanist. In the list following I observe the order of the "List of Plants known to occur on the Coast and in the Interior of the Labrador Peninsula," compiled by James M. Macoun, and published in the Annual Report of the Geological Survey of Canada, vol. viii., part L., Appendix vi. Nearly all the plants of our list are also on Macoun's list, which is compiled from at least four other lists—all except possibly four or five species and varieties. The list is as follows:

RANUNCULACEÆ.

Ranunculus aquatilis, Linn., var. trichophyllus, Chaix.
Coptis trifolia, Salisb.

CRUCIFERÆ.

Draba incana, Linn.
Cochlearia officinalis, Linn., var. Groenlandica.

VIOLACEÆ.

Viola canina, Linn., var. sylvestris, Regel.

CARYOPHYLLACEÆ.

Silene acaulis, Linn.
Lychnis alpina, Linn.
Arenaria Groenlandica, Spreng.
Arenaria peploides, Linn.
Stellaria longipes, Goldie.
Stellaria humifusa, Rottb.
Cerastium alpinum, Linn.

LEGUMINOSÆ.

Oxytropis campestris, Linn., var. caerulea.
Lathyrus maritimus, Bigel.

ROSACEÆ.

Rubus Chamaemorus, Linn.
Rubus articus, Linn.
Rubus strigosus, Michx.
Sibbaldia procumbens, Linn.

Potentilla Norvegica, Linn.
Potentilla maculata, Poir.
Potentilla palustris, Scop.
Potentilla tridentata, Sol.
Potentilla anserina, Linn.
Pyrus Americana, D. C.
Amelanchier Canadensis, T. and G., var. oligocarpa, T. and G.

SAXIFRAGACEÆ.

Saxifraga rivularis, Linn.
Parnassia palustris, Linn.
Ribes prostratum, L'Her.

CRASSULACEÆ.

Sedum Rhodiola, D. C.

HALORAGEÆ.

Hippuris vulgaris, Linn.

ONAGRACEÆ.

Epilobium latifolium, Linn.
Epilobium palustre, Linn.

UMBELLIFERÆ.

Archangelica Gmelini, D. C.

CORNACEÆ.

Cornus Canadensis, Linn.
Cornus Suecica, Linn.

CAPRIFOLIACEÆ

Viburnum pauciflorum, Pylaie.
Linnaea borealis, Gronov.
Lonicera caerulea, Linn.

COMPOSITÆ.

Solidago multiradiata, Ait.
Solidago.
Aster Novi Belgii, Linn.
Achillea Millefolium, Linn., var. nigrescens, E. Meyer.
Senecio Pseudo-Arnica, Less.
Taraxacum officinale, Weber, var. alpinum, Koch.

VACCINIACEÆ.

Vaccinium uliginosum, Linn.
Vaccinium Vitis-Idæa, Linn.
Vaccinium Oxycoccus, Linn.

ERICACEÆ.

Cassiope hypnoides, Don.
Andromeda polifolia, Linn.
Loiseleuria procumbens, Desv.
Bryanthus taxifolius, Gray.
Kalmia glauca, Ait.
Ledum palustre, Linn.
Ledum latifolium, Ait.

PRIMULACEÆ.

Primula farinosa, Linn.
Primula Mistassinica, Michaux.
Primula Egaliksensis, Hornem.
Trientalis Americana, Pursh.

GENTIANACEÆ.

Gentiana Amarella, Linn., var. acuta, Hook.
Pleurogyne rotata, Griesbach.
Menyanthes trifoliata, Linn.

BORRAGINACEÆ.

Mertensia maritima, Don.

SCROPHULARIACEÆ.

Veronica alpina, Linn.
Castilleia pallida, Kunth.
Euphrasia officinalis, Linn., var. Tartarica, Benth.
Pedicularis Groenlandica, Retz.
Pedicularis Lapponica, Linn.
Rhinanthus Crista-galli, Linn.

LENTIBULARIACEÆ.

Pinguicula vulgaris, Linn.
Pinguicula villosa, Linn.

PLANTAGINACEÆ.

Plantago maritima, Linn.

POLYGONIACEÆ.

Polygonum viviparum, Linn.

SANTALACEÆ.

Comandra livida, Rich.

ORCHIDACEÆ.

Habenaria hyberborea, R. Br.
Habenaria obtusata, Rich.
Habenaria dilatata, Gray.

IRIDACEÆ.

Iris Hookeri, Penny.

LILLIACEÆ.

Streptopus amplexifolius, D. C.
Tofieldia borealis, Wahl.

GRAMINEÆ.

Elymus mollis, Trin.

APPENDIX.—I.

LIST OF MEMBERS, 1898-99.

ORDINARY MEMBERS.

	Date of Admission.
Allison, Augustus, Halifax	Feb. 15, 1869
Anderson, James F., Dartmouth, N. S.	Jan. 2, 1894
Austen, James H., Crown Lands Department, Halifax	Jan. 2, 1894
Bayer, Rufus, Halifax	March 4, 1890
Bennett, Joseph	Nov. 3, 1886
Bishop, Watson L., Dartmouth, N. S	Jan. 6, 1890
Bliss, Donald M., Boston, U. S. A	Jan. 31, 1890
Bowman, Maynard, Public Analyst, Halifax	March 13, 1884
Brown, R. B., Yarmouth, N. S	Jan. 10, 1891
Butler, Professor W. R., C. E., Royal Military College, Kingston, Ont	Nov. 27, 1889
Campbell, Donald A., M. D., Halifax	Jan. 31, 1890
Campbell, George Murray, M. D., Halifax	Nov. 10, 1884
Clements, E. F., Yarmouth, N. S	Jan. 10, 1891
Cowie, A. J., M. D., L. R. C. P. E., Halifax	Jan. 27, 1893
DesBrisay, A. E., Halifax	Jan. 4, 1891
DeWolfe, James R., M. D., L. R. C. S. E., Halifax	Oct. 26, 1865
Dick, Alexander, M. E., Halifax	Nov. 29, 1894
Doane, F. W. W., City Engineer, Halifax	Nov. 3, 1886
Donkin, Hiram, C. E., Point Tupper, Cape Breton	Nov. 30, 1892
Egan, Thomas J., Halifax	Jan. 6, 1890
Elliott, Miss Bertha	March 4. 1895
Fearon, James, Principal, Deaf and Dumb Institution, Halifax	May 8, 1894
Finn, Wm. D., M. D., Halifax	Oct. 29, 1894
Faville, E. E.	Nov. 29, 1894
Forbes, John, Halifax	March 14, 1883
Foster, James G., Dartmouth, N. S	March 14, 1883
Fraser, C. F., Principal, School for the Blind, Halifax	March 31, 1890
Fraser, Rev. W. M., B. A., B. SC., Halifax	Nov. 29, 1894
Fyshe, Thomas, Montreal	Jan. 9, 1888
Gates, Herbert E., Architect, Dartmouth, N. S	April 17, 1899
Gilpin, Edwin, M. A., LL. D., F. R. S. C., Inspector of Mines, Halifax	April 11, 1873
Greer, T. A., M. D., Colborne, Ontario	April 7, 1893
Hall, Charles Frederick, Halifax	Dec. 31, 1894
Hare, Alfred A	Dec. 12, 1881
Harris Herbert, Vancouver, British Columbia	Jan. 31, 1880
Hattie, William Harrop, M. D., Halifax	Nov. 12, 1892
Hendry, William A., Jr., C. E., Halifax	Jan. 4, 1892
Irving, G. W. T., Halifax	Jan. 4, 1892
Jacques, Hartley S., M. D., Halifax	May 8, 1894
Johnston, H. W., C. E., Halifax	Dec. 31, 1894
Keating, E. H., C. E., City Engineer, Toronto, Ontario	April 12, 1882
Kennedy, W. T., Principal, County Academy, Halifax	Nov. 27, 1889

	Date of Admission.
Laing, Rev, Robert, Halifax	Jan. 11, 1885
Locke, Thomas J	Jan. 4, 1892
McColl, Roderick, C. E., Halifax	Jan. 4, 1892
Macdonald, Simon D., F. G. S.. Halifax	March 14, 1881
Macdonald, W. A., C. E., Halifax	April 17, 1899
MacGregor, Prof. J. G., M. A., D. SC., Dalhousie College, Halifax	Jan. 11, 1877
McInnes, Hector, LL. B., Halifax	Nov. 27, 1889
MacIntosh, Kenneth, Mabou, Cape Breton	Jan. 4, 1892
*McKay, Alexander, Supervisor of Schools, Halifax	Feb. 5. 1872
MacKay, A. H., B.A., B.SC., LL.D., F.R.S.C., Superintendent of Education, Halifax	Oct. 11, 1885
MacKay, Prof. Ebenezer, PH. D., Dalhousie College, Halifax	Nov. 27, 1889
McKerron, William, Halifax	Nov. 30, 1891
MacNab, William, Halifax	Jan 31, 1890
Marshall, G. R., Principal, Richmond School, Halifax	April 4, 1894
Mason, F. H., F. C. S.. Halifax	Dec. 31, 1894
Morrow, Arthur, M. D., Sand Coulée, Montana, U. S. A	Nov. 27, 1889
Morton, S. A., M. A., County Academy, Halifax	Jan. 27, 1893
Murphy, Martin, C. E., D. SC., Provincial Engineer, Halifax	Jan. 15, 1870
Newman, C. L., Dartmouth, N. S	Jan. 27, 1893
O'Hearn, P., Principal, St. Patrick's Boys' School, Halifax	Jan. 16, 1890
*Parker, Hon. Daniel McN., M. D., M. L. C., Dartmouth, N. S	1871
Pearson, B. F., Barrister, Halifax	March 31, 1890
Piers, Harry, Halifax	Nov. 2, 1888
Poole, Henry S., F. G. S., Stellarton, N. S.	Nov. 11, 1879
Read, Herbert H., M. D., L R. C. S., Halifax	Nov. 27, 1889
Ritchie. Thomas, C. E.	Jan. 2, 1894
Robb, D. W., M. E., Amherst, N. S.	March 4, 1890
Rutherford, John, M. E., Stellarton, N. S.	Jan. 8, 1865
Shine, Michael, Halifax	Dec. 3, 1891
Silver Arthur P., Halifax	Dec. 12, 1887
Silver, William C., Halifax	May 7, 1864
Smith, Capt. W. H., R. N. R., F. R. G. S., Halifax	Nov. 27, 1889
Spike, C. J., Halifax	May 8, 1894
Stewart, John, M. B. C. M., Halifax	Jan. 12, 1885
Tremaine, Harris S., Halifax	Jau. 2, 1894
Twining, Charles, Bank of B. N. A., Halifax	Dec. 3, 1896
Uniacke, Robert F., C. E.,	March 9, 1885
Weatherbe, Hon. Mr. Justice, Halifax	March 28, 1895
Wheaton, L. H., Chief Engineer, Coast Railway Co., Yarmouth, N. S.	Nov. 29, 1894
Willis, C. E., M. E.. Halifax	Nov. 29, 1894
Wilson, Robert J., Secretary, School Board, Halifax	May 3, 1889
Yorston, W. G., C. E., Truro, N. S	Nov. 12, 1892

ASSOCIATE MEMBERS.

Caie, Robert, Yarmouth, N. S.	Jan. 31, 1890
*Cameron, A., Principal of Academy, Yarmouth, N. S.	Nov. 27, 1889
Coldwell, Professor A. E., M. A., Acadia College, Wolfville, N. S	Nov. 27, 1889
DeWolfe, Melville G., Kentville, N. S.	May 2, 1895
Dickenson, S. S., Superintendent, Commercial Cable Co., Hazelhill, Guysborough Co., N. S	March 4, 1895
Eaton, F. H., M. A	Jan. 6, 1890
Edwards, Arthur M., M. D., F. L. S., Newark, N. J	Dec. 12, 1898

* Life Member.

Date of Admission.

Faribault, E. R., C. E., Ottawa, Ontario .... March 6, 1888
Fox, John J., Montreal .... May 8, 1882
Halliday, And., M. D., Shubenacadie, N. S .... Dec. 12, 1898
Hardman, John E., M. E., Montreal .... March 4, 1890
Harris, Prof. C., Royal Military College, Kingston, Ontario .... Nov. 13, 1881
Hunton, Prof. S. W., M. A., Mount Allison College, Sackville, N. B. .... Jan. 6, 1890
James, C. C., M. A., Dep. Min. of Agriculture, Toronto, Ontario .... Dec. 3, 1896
*Johns, Thomas W., Yarmouth, N. S .... Nov. 27, 1889
Kennedy, Prof. Geo. T., M. A., D.SC., F.G.S., King's College, Windsor, N.S. Nov. 9, 1882
McKenzie, W. B., C. E., Moncton, N. B .... March 31, 1882
McLeod, R. R., Brookfield, N. S .... Dec. 3, 1897
Magee, W. H., PH.D., High School, Parrsboro', N. S. .... Nov. 29, 1894
Matheson, W. G., M. E., New Glasgow, N. S. .... Jan. 31, 1890
Prest, W. H., Chester Basin, N. S .... Nov. 29, 1894
*Reid, A. P., M.D., L.R.C.S., Supt. Victoria Gen. Hospital, Halifax ...... Jan. 31, 1890
Rosborough, Rev. James, Musquodoboit Harbor, N. S. .... Nov. 29, 1894
Russell, Lee, B. S., Normal School, Truro, N. S .... Dec. 3, 1896
Smith, Prof. H. W., B.SC., Prov. Agricultural School, Truro, N. S. ... Jan. 6, 1890
Wilson, B. C., Waverley, N. S .... March 4, 1890

CORRESPONDING MEMBERS.

Ami, Henry M., D.SC., F.G.S., Ottawa, Ontario .... Jan. 2, 1892
Bailey, Prof. L. W., PH.D., LL.D., F. R. S. C., University of New Brunswick, Fredericton, N. B .... Jan. 6, 1890
Ball, Rev. E. H., Tangier, N. S. .... Nov. 29, 1871
Bethune, Rev. C. J. S., Port Hope, Ontario .... Dec. 29, 1868
Davidson, Prof. J., PHIL. D., Fredericton, N. B .... Dec. 12, 1898
Dawson, Sir J. W., C. M. G., LL.D., F. R. S., Montreal .... Jan. 31, 1890
Dobie, W. Henry, M. D., Chester, England .... Dec. 3, 1897
Duns, Prof. John, New College, Edinburgh, Scotland .... Dec. 30, 1887
Ells, R. W., LL.D., F.G.S.A., F.R.S.C., Geological Survey, Ottawa, Ont.. Jan. 2, 1894
Fletcher, Jas., LL.D., F. L. S., F. R. S. C., Entomologist and Botanist, Central Exp. Farm, Ottawa, Ont .... March 2, 1897
Fletcher, Hugh, B. A., Geological Survey, Ottawa, Ontario .... March 3, 1891
Ganong, Prof. W. F., B.A., PH.D., Smith College, Northampton, Mass., U. S. A .... Jan. 6, 1890
Harrington, W. Hague, F.R.S.C., Post Office Department, Ottawa ...... May 5, 1896
Harvey, Rev. Moses, LLD., F. R. S. C., St. John's, Newfoundland .... Jan. 31, 1890
King, Major, R. A. .... Nov. 19, 1877
Litton, Robert T., F. G. S., Melbourne, Australia .... May 5, 1892
McClintock, Vice-Admiral Sir Leopold, Kt., F. R. S .... June 10, 1880
Matthew, G. F., M. A., D.SC., F. R. S. C., St. John, N. B. .... Jan. 6, 1890
Maury, Rev. M., D.D., Ithaca, N. Y., U. S. A .... Nov. 30, 1891
Peter, Rev. Brother J., St. Joseph's Coll. Inst., Buffalo, N. Y .... Dec. 12, 1898
Prince, Prof. E. E., Commissioner and General Inspector of Fisheries, Ottawa, Ontario .... Jan. 5, 1897
Smith, Hon. Everett, Portland, Maine, U. S. A .... March 31, 1890
Spencer, Prof. J. W., PH. D., F. G. S., Washington, D. C., U. S. A. .... Jan. 31, 1890
Trott, Capt., S. S. "Minia," Anglo-American Telegraph Co .... Jan. 31, 1890
Waghorne, Rev. Arthur C., St. John's, Newfoundland .... May 5, 1892
Weston, Thomas C., F.G.S.A., Ottawa, Ontario .... May 12, 1877

* Life Member.

APPENDIX.—II.

LIST OF MEMBERS, 1899-1900.

ORDINARY MEMBERS.

	Date of Admission.		
Allison, Augustus, Halifax	Feb.	15,	1869
Austen, James H., Crown Lands Department, Halifax	Jan.	2,	1894
Bayer, Rufus, Halifax	March	4,	1890
Bishop, Watson L., Dartmouth, N. S	Jan.	6,	1890
Bliss, Donald M., Boston, U. S. A	Jan.	31,	1890
Bowman, Maynard, B. A., Public Analyst, Halifax	March	13,	1884
Brown, R. Balfour, Yarmouth, N. S	Jan.	10,	1891
Butler, Professor Wm. R , C. E., Royal Military College, Kingston, Ont.	Nov.	27,	1889
Campbell, Donald A., M. D., Halifax	Jan.	31,	1890
Campbell, George Murray, M. D., Halifax	Nov.	10,	1884
Clements, E. F., Yarmouth, N. S	Jan.	10,	1891
Cowie, Andrew J., M. D., L. R. C. P. E , Halifax	Jan.	27,	1893
DeWolfe, James R., M. D., L. R C. S. E., Halifax	Oct.	26,	1865
Dick, Alexander, M. E., Halifax	Nov.	29,	1894
Doane, F. W W., City Engineer, Halifax	Nov.	3,	1886
Donkin, Hiram, C. E., Point Tupper, Cape Breton	Nov.	30,	1892
Egan, Thomas J., Halifax	Jan.	6,	1890
Elliott, Miss Bertha, Dartmouth, N. S	March	4,	1895
Fearon, James, Principal Deaf and Dumb Institution, Halifax	May	8,	1894
Finn, Wm. D., M. D., Halifax	Oct.	29,	1894
Faville, E. E., President, National Farm School, Doylestown, Pa	Nov.	29,	1894
Forbes, John, Halifax	March	14,	1883
Foster, James G., Judge of Probate, Dartmouth, N. S	March	14,	1883
Fraser, C. F., Principal, School for the Blind, Halifax	March	31,	1890
Fraser, Rev. W, M., B. A., B. SC., Halifax	Nov	29,	1894
Gates, Herbert E., Architect, Dartmouth, N. S	April	5,	1899
Gilpin, Edwin, M. A., LL. D., F. R. S. C., Inspector of Mines, Halifax	April	11,	1873
Greer, T. A., M. D., Colborne, Ontario	April	7,	1893
Hall, Charles Frederick	Dec.	31,	1894
Hare, Alfred A	Dec.	12,	1881
Harris, Herbert, Vancouver, British Columbia	Jan.	31,	1880
Hattie, William Harrop, M. D., Halifax	Nov.	12,	1892
Hendry, William A., Jr., C. E., Windsor, N. S	Jan.	4,	1892
Irving, G. W. T., Halifax	Jan.	4,	1892
Jacques, Hartley S., M. D., Halifax	May	8,	1894
Johnston, Henry W , C E., Halifax	Dec.	31,	1894
*Keating, E. H., C. E., City Engineer, Toronto, Ontario	April	12,	1882
Kennedy, W. T., Principal, County Academy, Halifax	Nov.	27,	1889

* Life Member.

	Date of Admission.
Laing, Rev. Robert, Halifax	Jan. 11, 1885
Locke, Thomas J., Halifax	Jan. 4, 1892
McColl, Roderick, C. E., Halifax	Jan. 4, 1892
Macdonald, Simon D., F. G. S., Halifax	March 14, 1881
Macdonald, W. A., C. E., Sydney, C. B	April 5, 1899
MacGregor, Prof. James Gordon, M. A. D. SC., F. R. S., Dalhousie College, Halifax	Jan. 11, 1877
McInnes, Hector, LL. B., Halifax	Nov. 27, 1889
*McKay, Alexander, Supervisor of Schools, Halifax	Feb. 5, 1872
*MacKay, Alex. Howard, B. A., B. SC, LL. D, F. R. S. C., Superintendent of Education, Halifax	Oct. 11, 1885
MacKay, Prof. Ebenezer, Ph. D., Dalhousie College, Halifax	Nov. 27, 1889
McKerron, William, Halifax	Nov. 30, 1891
MacNab, William, Halifax	Jan. 31, 1890
Marshall, G. R., Principal, Richmond School, Halifax	April 4, 1894
Mason, F. H., F. C. S., Halifax	Dec. 31, 1891
Morrow, Arthur, M. D., Sand Coulée, Montana, U. S. A	Nov. 27, 1889
Morton, S. A., M. A., County Academy, Halifax	Jan. 27, 1893
Murphy, Martin, C. E., D. SC., Provincial Engineer, Halifax	Jan. 15, 1870
Newman, C. L., Dartmouth, N. S	Jan. 27, 1893
O'Hearn, Peter, Principal, St. Patrick's Boys' School, Halifax	Jan. 16, 1890
*Parker, Hon. Daniel McN., M. D., M. L. C., Dartmouth, N. S	1871
Pearson, B. F., Barrister, Halifax	March 31, 1890
Piers, Harry, Halifax	Nov. 2, 1888
*Poole, Henry S., F. G. S, F. R. S. C, Stellarton, N. S	Nov. 11, 1872
Read. Herbert H., M. D., L R. C. S., Halifax	Nov. 27, 1889
*Robb, D. W., M. E., Amherst, N. S	March 4, 1890
Rutherford, John, M. E., Stellarton, N. S	Jan, 8, 1865
Shine, Michael, Halifax	Dec. 3, 1891
Silver, Arthur P., Halifax	Dec. 12, 1887
Silver, William C., Halifax	May 7, 1864
Smith, Capt. Wm Henry, R. N. R, F. R G. S., Halifax	Nov. 27, 1889
Stewart, John, M. B., C. M., Halifax	Jan. 12, 1885
Tremaine Harris S., Halifax	Jan. 2, 1894
Weatherbe, Hon. Mr. Justice, Halifax	March 28, 1895
Wheaton, L. H., Chief Engineer, Coast Railway Co, Yarmouth, N. S	Nov. 29, 1894
Willis, C. E., M. E., Halifax	Nov. 29, 1894
Wilson, Robert J., Secretary, School Board, Halifax	May 3, 1889
*Yorston, W. G., C. E., Truro, N. S	Nov. 12, 1892

ASSOCIATE MEMBERS.

*Caie, Robert, Yarmouth, N. S	Jan. 31, 1890
*Cameron, A., Principal of Academy, Yarmouth, N. S	Nov. 27, 1889
Coldwell, Professor A. E., M. A, Wolfville, N. S	Nov. 27, 1889
DeWolfe, Melville G., Kentville, N. S	May 2, 1895
*Dickenson, S. S., Superintendent, Commercial Cable Co., Hazelhill, Guysborough Co., N. S	March 4, 1895
Eaton, F. H., M A., Superintendent of Public Schools, Victoria, B. C	Jan. 6, 1890
Edwards, Arthur M., M. D., F. L. S, Newark, N. J	Dec 6, 1898
Faribault, E. R., C. E., Ottawa, Ontario	March 6, 1888
Halliday, And, M. D., Shubenacadie, N. S	Dec. 6, 1898
Hardman, John E., M. E., Montreal	March 4, 1890

* Life Member.

	Date of Admission.		
Haycock, Prof. Ernest, Acadia College, Wolfville, N. S	May	17,	1899
Hunton, Prof. S. W., M. A., Mount Allison College, Sackville, N. B	Jan.	6,	1890
James, C. C., M. A., Dep. Min. of Agriculture, Toronto, Ontario	Dec.	3,	1896
*Johns, Thomas W., Yarmouth, N. S	Nov.	27,	1889
Kennedy, Prof. Geo. T., M. A., D. SC., F. G. S., King's College, Windsor, N. S.	Nov.	9,	1882
MacIntosh, Kenneth, St. George's Channel, Richmond Co., C. B	Jan.	4,	1892
McKenzie, W. B., C. E., Moncton, N. B	March	31,	1882
McLeod, R. R., Brookfield, N. S	Dec.	3,	1897
Magee, W. H., Ph. D., High School, Parrsboro', N. S	Nov.	29,	1894
Matheson, W. G., M. E., New Glasgow, N. S.	Jan.	31,	1890
Prest, Walter H., Bedford, N. S	Nov.	29,	1894
*Reid, Alex. P., M. D., L. R. C. S., Middleton, N. S	Jan.	31,	1890
Rosborough, Rev. James, Musquodoboit Harbor, N. S	Nov.	29,	1894
Russell, Lee, B. S., Normal School, Truro, N. S	Dec.	3,	1896
Smith, Prof. H. W., B. SC., Prov. Agricultural School, Truro, N. S	Jan.	6,	1890

CORRESPONDING MEMBERS.

Ami, Henry M., D. SC., F. G. S., Ottawa, Ontario	Jan.	2,	1892
Bailey, Prof. Loring Wort, Ph. D., LL. D., F. R. S. C., University of New Brunswick, Fredericton, N. B	Jan.	6,	1890
Ball, Rev. Edward H., Tangier, N. S	Nov.	29,	1871
Bethune, Rev. C. J. S., Port Hope, Ontario	Dec.	29,	1868
Davidson, Prof. John, Phil. D., Univ. of N. Brunswick, Fred'ton, N. B.	Dec.	12,	1898
Dobie, W. Henry, M. D., Chester, England	Nov.	3,	1897
Duns, Prof. John, LL. D., F. R. S. E., New College, Edinburgh, Scotland	Dec.	30,	1887
Ells, R. W., LL. D., F. G. S. A., F. R. S. C., Geological Survey, Ottawa, Ont	Jan.	2,	1894
Fletcher, Jas., LL. D., F. L. S., F. R. S. C., Entomologist and Botanist, Central Exp. Farm, Ottawa, Ont	March	2,	1897
Fletcher, Hugh, B. A., Geological Survey, Ottawa, Ontario	March	3,	1891
Ganong, Prof. Wm. F., B. A., Ph. D., Smith College, Northampton, Mass., U. S. A	Jan.	6,	1890
Harrington, Wm. Hague, F. R. S. C., Post Office Department, Ottawa	May	5,	1896
Harvey, Rev. Moses, LL. D., F. R. S. C., St. John's, Newfoundland	Jan.	31,	1890
King, Major, R. A.	Nov.	19,	1877
Litton, Robert T., F. G. S., Melbourne, Australia	May	5,	1892
McClintock, Vice-Admiral Sir Leopold, Kt., F. R. S.	June	10,	1880
Matthew, G. F., M. A., D. SC., F. R. S. C., St John, N. B	Jan.	6,	1890
Maury, Rev. Mytton, D. D., Ithaca, N. Y., U. S. A.	Nov.	30,	1891
Peter, Rev. Brother Junian, St. Joseph's Commercial College, Detroit, Mich	Dec.	12,	1898
Pickford, Charles, Halifax	March	2,	1900
Prince, Prof. E. E., Commissioner and General Inspector of Fisheries, Ottawa, Ontario	Jan.	5,	1897
Smith, Hon. Everett, Portland, Maine, U. S. A	March	31,	1890
Spencer, Prof. J. W., Ph. D., F. G. S., Washington, D. C., U. S. A	Jan.	31,	1890
Waghorne, Rev. Arthur C., St. John's, Newfoundland	May	5,	1892
Weston, Thomas C., F. G. S. A., Ottawa, Ontario	May	12,	1877

* Life Member.

APPENDIX.—III.

LIST OF MEMBERS, 1900-01.

ORDINARY MEMBERS.

	Date of Admission.
Allison, Augustus, Halifax	Feb. 15, 1869
Austen, James H., Crown Lands Department, Halifax	Jan. 2, 1894
Bayer, Rufus, Halifax	March 4, 1890
Bishop, Watson L., Dartmouth, N. S.	Jan. 6 1890
Bowman, Maynard, Public Analyst, Halifax	March 13, 1884
Brown, R. Balfour, Yarmouth, N. S	Jan. 10, 1891
*Campbell, Donald A., M D,, Halifax	Jan. 31, 1890
Campbell, George Murray, M. D., Halifax	Nov. 10, 1884
Cowie, Andrew J., M. D., L. R. C. P. E., Halifax	Jan. 27, 1893
*Davis, Charles Henry, C. E., New York City, U. S. A.	Dec. 5, 1900
Doane, F. W. W., City Engineer, Halifax	Nov. 3, 1886
Donkin, Hiram, C. E., Glace Bay, Cape Breton	Nov. 30, 1892
Edwards, George M., B.SC, Halifax	March 6, 1901
Egan, Thomas J., Halifax	Jan. 6, 1890
Elliott, Miss Bertha, Dartmouth, N. S	March 4, 1895
Fearon, James, Principal, Deaf and Dumb Institution, Halifax	May 8, 1894
Finn, Wm D., M. D., Halifax	Oct. 29, 1894
*Forbes, John, Halifax	March 14, 1883
Foster, James G., Dartmouth, N. S	March 14, 1883
Fraser, C. Frederick, Principal, School for the Blind, Halifax	March 31, 1890
Gates, Herbert E., Architect, Dartmouth, N. S	April 17, 1899
*Gilpin, Edwin, M. A., LL.D., F. R. S. C., Inspector of Mines, Halifax	April 11, 1873
Hattie, William Harrop, M. D., Dartmouth	Nov. 12, 1892
Hendry, William A., Jr., C. E, Windsor, N. S	Jan. 4, 1892
Irving, G. W. T., Halifax	Jan. 4, 1892
Jacques, Hartley S., M. D., Halifax	May 8, 1894
Johnston, Harry W., C. E., Halifax	Dec. 31, 1894
Laing, Rev. Robert, Halifax	Jan. 11, 1885
Locke, Thomas J., Halifax	Jan. 4, 1892
McColl, Roderick, C. E., Halifax	Jan. 4, 1892
Macdonald, Simon D., F. G. S., Halifax	March 14, 1881
McDonald, W A., C. E., Halifax	April 17, 1899
MacGregor. Prof. J. G., M. A., D. SC., Dalhousie College, Halifax	Jan. 11, 1877
McInnes, Hector, LL.B., Halifax	Nov. 27, 1889
*McKay, Alexander, Supervisor of Schools, Halifax	Feb. 5, 1872
*MacKay, A. H., B. A., B.SC., LL.D., F. R. S. C., Superintendent of Education, Halifax	Oct. 11, 1885
MacKay, Prof. Ebenezer, PH. D., Dalhousie College, Halifax	Nov. 27, 1889
McKerron, William, Halifax	Nov. 30, 1891
MacNab, William, Halifax	Jan. 31, 1890

* Life Member.

	Date of Admission.	
Marshall, Gilford R., Principal, Richmond School, Halifax	April	4, 1894
Mason, Francis H., F. C. S., Halifax	Dec.	31, 1894
Morton, S. A., M. A., County Academy, Halifax	Jan.	27, 1893
Murphy, Martin, C. E., D.SC., Provincial Engineer, Halifax	Jan.	15, 1870
Newman, C. L., Dartmouth, N. S.	Jan.	27, 1893
O'Hearn, Peter, Principal, St. Patrick's Boys' School, Halifax	Jan.	16, 1890
*Parker, Hon. Daniel McN., M. D., M. L. C., Dartmouth, N. S		1871
Pearson, B. F., Barrister, Halifax	March	31, 1890
Piers, Harry, Curator, Provincial Museum, Halifax	Nov.	2, 1888
*Poole, Henry S., A. M., ASSOC. R. S. M., F. G. S., F. R. S. C., M. CAN. SOC. C. E., HON. MEM. INST. M. E., Halifax	Nov.	11, 1872
Read, Herbert H., M. D., L. R. C. S., Halifax	Nov.	27, 1889
*Robb, D. W., M. E., Amherst, N. S	March	4, 1890
Rutherford, John, M. E., Windsor, N. S	Jan.	8, 1865
Silver, Arthur P., Halifax	Dec.	12, 1887
Silver, William C., Halifax	May	7, 1864
Smith, Prof. H. W., B. SC., Prof. Agricultural School, Truro, N. S., Assoc. Memb., Jan. 6, 1890	Dec.	1900
*Stewart, John, M. B. C. M Halifax	Jan.	12, 1885
Weatherbe, Hon. Mr. Justice, Halifax	March	28, 1895
Wheaton, L. H., Chief Engineer, Coast Railway Co., Yarmouth, N. S.	Nov.	29, 1894
Willis, C. E., M. E., Halifax	Nov.	29, 1894
Wilson, Robert J., Secretary, School Board, Halifax	May	3, 1889
*Yorston, W. G., C. E, Sydney, C. B	Nov.	12, 1892

ASSOCIATE MEMBERS.

*Caie, Robert Yarmouth, N. S	Jan.	31, 1890
*Cameron, A., Principal of Academy, Yarmouth, N. S	Nov.	27, 1889
Coldwell, A. E., M. A., Wolfville, N. S	Nov.	27, 1889
*Dickenson, S. S., Superintendent, Commercial Cable Co., Hazelhill, Guysborough Co., N. S	March	4, 1895
Edwards, Arthur M., M. D., F. L. S., Newark, N. J	Dec.	12, 1898
Faribault, E. R., B. A. SC. (Laval), Ottawa, Ontario	March	6, 1888
Halliday, Andrew, M. D., Shubenacadie, N. S	Dec.	12, 1898
Haycock, Prof. Ernest, Acadia College, Wolfville, N. S	May	17, 1899
Hunton, Prof. S. W. M. A., Mount Allison College, Sackville, N. B.	Jan.	6, 1890
Jaggar, Miss A. Louise, Smith Cove, Digby Co., N. S	Dec.	5, 1900
James, C. C., M. A., Dep Min. of Agriculture, Toronto, Ontario	Dec.	3, 1896
*Johns, Thomas W., Yarmouth, N. S	Nov.	27, 1889
*Keating, E. H., C. E., City Engineer, Toronto, Ont., Ord Memb., April 12, 1882	April	11, 1900
*Kennedy, Prof. Geo. T., M. A., D. SC., F. G. S., King's College, Windsor, N. S	Nov.	9, 1882
MacIntosh, Kenneth, St. George's Channel, C. B, Ord. Memb, Jan. 4, 1892	June,	1900
McKenzie, W. B., C. E., Moncton, N. B	March	31, 1882
McLeod, R. R., Brookfield, N. S	Dec.	3, 1897
Magee, W. H., PH. D., High School, Parrsboro', N. S	Nov.	29, 1894
Matheson, W. G., M. E., New Glasgow, N. S	Jan.	31, 1890
*Reid, A. P., M. D., L. R. C. S, Middleton, Annapolis Co., N. S	Jan.	31, 1890
Rosborough, Rev. James, Musquodoboit Harbour, N. S	Nov.	29, 1894
Russell, Prof. Lee, B. S, Normal School, Truro, N. S	Dec.	3, 1896
Sawyer, Prof. Everett W., Acadia College, Wolfville, N. S	Feb	6, 1901
Sears, Prof. F. C., Director N. S. School of Horticulture, Wolfville, N. S.	Feb.	6, 1901

* Life Member.

CORRESPONDING MEMBERS.

	Date of Admission.
Ami, Henry M., D. SC., F G.S., F.R.S.C., Ottawa, Ontario	Jan. 2, 1892
Bailey, Prof. L. W., PH D., LL.D, F R.S.C., University of New Brunswick, Fredericton, N. B	Jan. 6, 1890
Ball, Rev. E. H., Westville, N. S	Nov. 29, 1871
Bethune, Rev. C. J. S., M.A., D.C.L., F.R.C.S., London, Ontario	Dec 29, 1868
Davidson, Prof. John, PHIL. D., Fredericton, N. B.	Dec. 12, 1898
DeWolf, James R., M.D., L.R.C S E., Halifax, Ord. Memb., Oct. 26, 1865	Nov. 2, 1900
Dobie, W. Henry, M. D., Chester, England	Dec. 3, 1897
Duns, Prof. John, New College, Edinburgh, Scotland	Dec. 30, 1887
Ells, R. W., LL.D., F G S.A., F.R.S.C., Geological Survey, Ottawa, Ont.	Jan. 2, 1894
Fletcher, Hugh, B. A., Geological Survey. Ottawa, Ontario	March 3, 1891
Fletcher, James, LL D., F. L. S., F.R S.C, Entomologist and Botanist, Central Exp. Farm, Ottawa, Ontario	March 2, 1897
Ganong, Prof. W. F., B.A., PH.D., Smith College, Northampton, Mass., U. S. A.	Jan. 6, 1890
Harrington, W. Hague, F.R.S.C., Post Office, Department, Ottawa	May 5, 1896
Harvey, Rev. Moses, LL.D, F R S.C., St. John's, Newfoundland	Jan. 31, 1890
Litton, Robert T., F.G S., Melbourne, Australia	May 5, 1892
McClintock, Vice-Admiral Sir Leopold, Kt., F.R.S	June 10, 1880
Matthew, G. F., M. A., D SC, F.R.S.C., St. John, N. B	Jan. 6, 1890
Maury, Rev. Mytton, D D., Ithaca, N. Y., U.S. A	Nov. 30, 1891
Peter, Rev. Brother Junian, St. Joseph's Commercial College, Detroit, Mich.	Dec. 12, 1898
Pickford, Charles, Halifax	Mar. 2, 1900
Prest, Walter H., M. E., Bedford, Assoc. Memb., Nov. 29, 1894	Nov. 2, 1900
Prince, Prof. E. E., Commissioner and General Inspector of Fisheries, Ottawa, Ontario	Jan. 5, 1897
Smith, Hon. Everett, Portland, Maine, U. S. A	March 31, 1890
Spencer, Prof. J. W., PH. D., F. G S., Washington, D. C., U. S. A	Jan. 31, 1890
Weston, Thomas C., F. G. S. A., Ottawa, Ontario	May 12, 1877

APPENDIX.—IV.

LIST OF MEMBERS. 1901-02.

ORDINARY MEMBERS.

	Date of Admission.
Allison, Augustus, Halifax	Feb. 15, 1869
Austen, James H., Crown Lands Department, Halifax	Jan. 2, 1894
Bayer, Rufus, Halifax	March 4, 1890
Bishop, Watson L., Dartmouth, N. S.	Jan. 6 1890
Bowman, Maynard, B. A., Public Analyst, Halifax	March 13, 1884
Brown, R. Balfour, Yarmouth, N. S	Jan. 10, 1891
*Campbell, Donald A., M D., Halifax	Jan. 31, 1890
Campbell, George Murray, M. D., Hallfax	Nov. 10, 1884
Cowie, Andrew J., M. D., L. R. C. P. E, Halifax	Jan. 27, 1893
*Davis, Charles Henry, C. E., New York City, U. S. A	Dec. 5 1900
Dixon, Prof. Stephen Mitchell, B. A., B. A. I., Dalhousie College, Halifax	April 8, 1902
Doane, F. W. W., City Engineer, Halifax	Nov. 3, 1886
Donkin, Hiram, C. E., Antigonish, N. S	Nov. 30, 1892
Egan, Thomas J., Halifax	Jan. 6, 1890
Elliott, Miss Bertha, Dartmouth, N. S	March 4, 1895
Fearon, James, Principal, Deaf and Dumb Institution, Halifax	May 8, 1894
F nn, Wm D., M. D., Halifax	Oct. 29 1894
*Forbes, John, Halifax	March 14, 1883
Foster, James G., Dartmouth, N. S	March 14, 1883
Fraser, C. Frederick, Principal, School for the Blind, Halifax	March 31, 1890
Gates, Herbert E., Architect, Dartmouth, N. S.	April 17, 1899
*Gilpin, Edwin, M. A., LL.D., F. R S. C., Inspector of Mines, Halifax	April 11, 1873
Hattie, William Harrop, M. D., Dartmouth	Nov. 12, 1892
Hendry, William A., Jr, C. E, Windsor, N. S	Jan. 4, 1892
Irving, G. W. T., Education Dept., Halifax	Jan. 4, 1892
Jacques, Hartley S., M. D., Halifax	May 8, 1894
Johnston, Harry W., C. E., Halifax	Dec. 31, 1894
*Laing, Rev. Robert, Halifax	Jan. 11, 1885
Locke, Thomas J., Halifax	Jan. 4, 1892
McCarthy, J. B., B. A., B. SC., teacher of Science, County Academy, Halifax	Dec. 4, 1901
McColl, Roderick, C. E., Assistant Provl. Engineer, Halifax	Jan. 4, 1892
Macdonald, Simon D., F. G. S., Halifax	March 14, 1881
McDonald, W. A, C. E., Sydney	April 17, 1899
*MacGregor, Prof. J. G., M. A., D. SC., F. R. S., F. R. S. C., Edinburgh University, Edinburgh	Jan. 11, 1877
McInnes, Hector, LL.B., Halifax	Nov. 27, 1889
*McKay, Alexander, Supervisor of Schools, Halifax	Feb. 5, 1872
*MacKay, A. H, B. A., B.SC., LL.D., F. R. S. C., Superintendent of Education, Halifax	Oct. 11, 1885
MacKay, Prof. Ebenezer, PH. D., Dalhousie College, Halifax	Nov. 27, 1889

* Life Member.

Date of Admission.

McKerron, William, Halifax .... Nov. 30, 1891
MacNab, William, Halifax .... Jan. 31, 1890
Marshall, Gilford R., Principal, Richmond School, Halifax .... April 4, 1894
Morton, S. A., M. A., County Academy, Halifax .... Jan. 27, 1893
Murphy, Martin, C. E., D SC, Provincial Engineer, Halifax .... Jan. 15, 1870
Newman, C L., Dartmouth, N. S .... Jan. 27, 1893
O'Hearn, Peter, Principal, St. Patrick's Boys' School, Halifax .... Jan. 16, 1890
*Parker, Hon. Daniel McN., M. D., M. L. C., Dartmouth, N. S 1871
Pearson, B. F., Barrister, Halifax .... March 31, 1890
Piers, Harry, Curator Provincial Museum and Librarian Science Library, Halifax .... Nov. 2, 1888
*Poole, Henry S., A. M., ASSOC. R. S. M., F. G. S., F. R. S. C., M. CAN. SOC. C. E., HON. MEM. INST. M. E., Halifax .... Nov. 11, 1872
Read, Herbert H., M. D., L. R. C. S., Halifax .... Nov. 27, 1889
*Robb, D. W., M. E., Amherst, N. S .... March 4, 1890
Rutherford, John, M. E., Windsor, N. S .... Jan 8, 1865
Silver, Arthur P., Halifax .... Dec. 12, 1887
Silver, William C. Halifax .... May 7, 1864
*Smith, Prof. H.W., B SC., Prof. Agricultural School, Truro, N.S.; Assoc. Memb., Jan. 6, 1890 .... Dec. 1900
*Stewart, John, M. B. C. M., Halifax .... Jan. 12, 1885
Weatherbe, Hon. Mr. Justice, Halifax .... March 28, 1895
Wheaton, L. H., Chief Engineer, Coast Railway Co., Yarmouth N S .... Nov. 29, 1894
Wilson, Robert J., Secretary, School Board, Halifax .... May 3, 1889
* orston, W. G., C. E, Sydney, C. B .... Nov. 12, 1892

ASSOCIATE MEMBERS.

*Caie, Robert, Yarmouth, N. S .... Jan. 31, 1890
*Cameron, A., Principal of Academy, Yarmouth, N. S .... Nov. 27, 1889
Coldwell, A. E, M. A., Wolfville, N. S .... Nov. 27, 1889
*Dickenson, S. S., Superintendent, Commerc'al Cable Co., Hazelhill, Guysborough Co., N. S .... March 4, 1895
Edwards, Arthur M., M. D., F. L. S., Newark, N J .... Dec. 12, 1898
Faribault, E. R., B. A. SC. (Laval), Geological Survey, Ottawa, Ontario .... March 6, 1888
Haley, Prof. Frank R., Acadia College, Wolfville, N. S .... Nov. 5, 1901
Halliday, Andrew, M. D., Halifax, N. S .... Dec. 12, 1898
Haycock, Prof. Ernest, Acadia College, Wolfville, N. S .... May 17, 1899
Hunton, Prof. S. W., M. A., Mount Allison College, Sackville, N. B .... Jan. 6, 1890
Jaggar, Miss A. Louise, Cambridge, Mass. .... Dec. 5, 1900
James, C. C., M. A., Depy. Min. of Agriculture, Toronto, Ontario .... Dec. 3, 1896
*Johns, Thomas W., Yarmouth, N. S .... Nov. 27, 1889
*Keating, E H, C. E., Toronto Ry. Co., Toronto, Ont.; Ord. Memb., April 12, 1882 .... April 11, 1900
*Kennedy, Prof. Geo. T., M. A., D. SC., F. G. S., King's College, Windsor, N. S .... Nov. 9, 1882
MacIntosh, Kenneth, St. George's Channel, C. B; Ord. Memb, Jan. 4, 1892 .... June, 1900
*MacKay, Hector H., M. D., New Glasgow, N S .... Feb. 4, 1902
McKenzie, W. B., C. E., Moncton, N B .... March 31, 1882
McLeod, R. R., Brookfield, N. S .... Dec. 3, 1897
Magee, W. H., PH. D., High School, Parrsboro', N. S .... Nov. 29, 1894
Matheson, W. G., M. E., New Glasgow, N S .... Jan. 31, 1890
Payzant, E. N., M. D., Wolfville, N. S .... April 8, 1902

* Life Member.

Date of Admission.

Pineo, Avard V., LL. B., Kentville, N. S....... ....Nov. 5, 1901
*Reid, A. P., M. D., L.R.C.S, Middleton, Annapolis Co., N. S..........Jan. 31, 1890
*Rosborough, Rev. James, Musquodoboit Harbour, N. S..................Nov. 29, 1894
Russell, Prof. Lee, B.S., Worcester, Mass. ....Dec. 3, 1896
Sawyer, Prof. Everett W., Acadia College, Wolfville, N. S.............Feb 6, 1901
Sears, Prof. F. C., Director N. S. School of Horticulture, Wolfville, N. S. Feb. 6, 1901

CORRESPONDING MEMBERS.

Ami, Henry M., D. SC., F.G.S., F.R.S.C., Geological Survey, Ottawa, Ontario..Jan. 2, 1892
Bailey, Prof. L. W., PH D., LL.D., F.R.S.C., University of New Brunswick, Fredericton, N. B...Jan. 6, 1890
Ball, Rev. E. H., Westville, N. S..... ....Nov. 29, 1871
Bethune, Rev. C. J. S., M.A., D.C.L., F.R.C.S., London, Ontario........Dec 29, 1868
Davidson, Prof. John, PHIL. D., Univ. of N. B., Fredericton, N. B. ....Dec. 12, 1898
Dobie, W. Henry, M. D., Chester, England...................................Dec. 3, 1897
Duns, Prof. John, New College, Edinburgh, Scotland.....................Dec. 30, 1887
Ells, R. W., LL.D., F.G.S.A., F.R.S.C., Geological Survey, Ottawa, Ont. Jan. 2, 1894
Fletcher, Hugh, B. A., Geological Survey. Ottawa, Ontario............ March 3, 1891
Fletcher, James, LL. D., F. L. S., F.R.S.C., Entomologist and Botanist, Central Exp. Farm, Ottawa, Ontario.............................March 2, 1897
Ganong, Prof. W. F., B. A., PH.D., Smith College, Northampton, Mass., U. S. A.... ... .Jan. 6, 1890
Harrington, W. Hague, F.R.S.C., Post Office Department, Ottawa ......May 5, 1896
Litton, Robert T., F.G.S., Melbourne, Australia ....May 5, 1892
McClintock, Vice-Admiral Sir Leopold, Kt., F.R.S.........................June 10, 1880
Matthew, G. F., M. A., D. SC., F.R.S.C., St. John, N. B....................Jan. 6, 1890
Maury, Rev. Mytton, D. D., Ithaca, N. Y., U. S. A.........................Nov. 30, 1891
Peter, Rev. Brother Junian, St. Joseph's Collegiate Institute, Buffalo, N. Y..Dec. 12, 1898
Pickford, Charles, Halifax ....Mar. 2, 1900
Prest, Walter H., M. E., Bedford; Assoc. Memb., Nov. 29, 1894 ....Nov. 2, 1900
Prichard, Arthur H. Cooper, Museum of Brooklyn Inst. of Arts and Sciences, Brooklyn, N. Y...Dec. 4, 1901
Prince, Prof. E. E., Commissioner and General Inspector of Fisheries, Ottawa, Ontario ....Jan. 5, 1897
Smith, Hon. Everett, Portland, Maine, U. S. A........................... March 31, 1890
Spencer, Prof. J. W., PH. D., F. G. S., Washington, D. C., U. S. A........Jan. 31, 1890
Weston, Thomas C., F. G. S. A., Ottawa, Ontario..........................May 12, 1877

INDEX.

VOL. X.

(Roman numerals refer to the Proceedings ; Arabic numerals to the Transactions.)

PAGE

Agricultural credit. By Prof. J. Davidson, Phil. D 458
Air, school-room. By L Russell, B. Sc. xxi
Ambrose, *Rev.* John, *D. C. L.*, obituary notice of. By A. McKay iv
Ami, Henry M., *D. Sc.*—Description of tracks (*Ichthyoidichnites acadiensis*, n. sp.) from the fine-grained siliceous mudstones of the Knoydart formation (Eo-Devonian) of Antigonish County, N. S.......... .. 330
Subdivisions of Carboniferous system in eastern Canada, with special reference to position of Union and Riversdale formations of Nova Scotia, referred to Devonian system by some Canadian geologists. 162
Upper Cambrian age of Dictyonema slates of Angus Brook, New Canaan and Kentville, N. S......... 447
Angus Brook, N. S , Notes on Dr Ami's paper on Dictyonema slates of. By H. S. Poole.. 451
Angus Brook, N. S , Upper Cambrian age of Dictyonema slates of. By H. M. Ami, *D. Sc.* 447
Antigonish County, N. S., Tracks from Knoydart formation of. By H. M. Ami, D. Sc....................... 330
Ants, Periodical appearance of, in a chimney. By H. S. Poole.... xlix
Aqueous solutions. *See* Lindsay, C. F............................ 205
Archibald, E. H., *M. Sc.*—On a test, by the freezing-point method, of the ionization coefficients determined by the conductivity method, for solutions containing potassium and sodium sulphates 33
Atlantic, Material taken from the bottom of. By A H. MacKay, LL. D.. 1
Barnes, James, *B. A.*—On the calculation of the conductivity of aqueous solutions containing hydrochloric and sulphuric acids 129
On the conductivity, specific gravity and surface tension of aqueous solutions containing potassium chloride and sulphate............ 49
On the depression of freezing-point by mixtures of electrolytes 139
On the Relation of the viscosity of mixtures of solutions of certain salts to their state of ionization 113
Bee's nest, Unusual site for. By H. S. Poole, F. G. S xlix

PAGE

Bishop, Watson L.—Exhibition of a collection of Nova Scotian birds' eggs, and remarks thereon. (Title only) lxviii
Star-nosed Mole *(C. cristata)*, its breeding habits, etc. 348
Boehner, R. S., *B. Sc.*—Standardization of Hydrochloric Acid with Borax. (Title only) ci
Botrychium ternatum, Condensed form of. By A. H. MacKay, LL. D. xcix
Branch Societies, formation of authorised lxviii
Branch of Institute at Wolfville, Report on. By Prof. E. Haycock xcviii
Purposes and Aims of By Prof. E. Haycock cix
Calyx drill. *See* Weatherbe, D'A., on Nictaux iron field 352
Cambrian slates of Halifax, Worm trails in. By H. S. Poole 453
Cape Breton coals, Notes on effect of washing. By H. S. Poole, F.R S.C. 245
Carboniferous system of eastern Canada, On the sub-divisions of. By A. H. MacKay, LL. D. xlvii
Carboniferous system, Sub-divisions of, in eastern Canada, with special reference to position of Union and Riversdale formations of Nova Scotia, referred to Devonian system by some Canadian geologists. By H. M. Ami, D. Sc. 162
Chylomycterus schœpfi. *See* Piers, H 110
Coals, Notes on effect of washing certain Cape Breton. By H. S. Poole, F. R. S. C 245
Condensed form of *Botrychium ternatum*. By A. H. MacKay, LL. D. xcix
Conductivity, specific gravity and surface tension of aqueous solutions containing potassium chloride and sulphate. By J. Barnes 49
Conductivity. *See* Barnes, J. 129
Condylura cristata, Star-nosed mole, its breeding habits, etc. By W. L. Bishop 348
Conglomerate, New Glasgow. By H. Fletcher 323
Consumption and expenditure in Canada, Statistics of. By Prof. J. Davidson ....
Copper sulphate, Solutions of. *See* Lindsay, C. F 205
Credit, Agricultural. By Prof. J. Davidson, Phil. D. 458
Davidson, *Prof.* John, *Phil. D.*—Agricultural credit 458
Natural history of Money 179
Statistics of expenditure and consumption in Canada 1
Dawson, *Sir* J William, obituary notice of. By A. McKay xxxvi
Resolution on death of xlvi
Depression of freezing-point by mixtures of electrolytes. By J. Barnes .. 139
Depression of freezing-point for electrolytes. By Prof. J. G. MacGregor.. 211
Determination ot freezing-point depression constant for electrolytes. By T. C. Hebb 409
Determination of freezing-point depressions of dilute solutions of electrolytes. By T. C. Hebb 422
Devonian, The : geological nomenclature in Nova Scotia. By H. Fletcher, B. A. 235

PAGE

Devonian system in Nova Scotia. *See under* Ami, H. M., Sub-divisions of Carboniferous system 162
DeWolfe, Dr. James R., Death of .... lxi, lxxxiv
Diagram of freezing-point depressions for electrolytes. By Prof. J. G. MacGregor 211
Diatomaceæ of Nova Scotia. By A. H. Mackay, LL. D xix
Dictyonema slates of Angus Brook, New Canaan, and Kentville, N. S., Notes on Dr. Ami's paper on. By H. S. Poole 451
Dictyonema slates of Angus Brook, New Canaan, and Kentville, N. S., Upper Cambrian age of. By H. M. Ami, D. Sc 447
Doane, F. W. W.—Rainfall notes, Nova Scotia 399
Downs, Andrew, founder of the first zoological garden in America, Sketch of. By H. Piers cii
Drift ice as an eroding and transporting agent. By W. H. Prest 333
Drift ice as an eroding and transporting agent, Supplementary notes on. By W. H. Prest 455
Early intervale flora of eastern Nova Scotia. By C. B. Robinson 502
Earths, The rare. By W. H. Magee, Ph. D lxii
Edwards, *Dr.* A. M.—Infusorial earths of the world and the iceberg period. (Title only.) xix
Elastic properties of india-rubber. *See* India-rubber.
Election of officers for 1898-9, xvii. 1899-1900, xlvi. 1900-01, lviii. 1901-02, xcviii.
Electrolytes, Depression of freezing-point by mixtures of. By J. Barnes .. 139
Electrolytes, Determination of freezing-point depression constant for. By T. C. Hebb 409
Electrolytes, Determination of freezing-point depression of dilute solutions of. By T. C. Hebb 422
Electrolytes, Diagram of freezing-point depressions for. By Prof. J. G. MacGregor 211
Ells, R. W., *LL. D.*—Progress of geological investigation in Nova Scotia. 433
Erosion and transportation. *See* Drift ice.
Expenditure and consumption in Canada, Statistics of. By Prof. J. Davidson 1
Fish *(Chylomycterus schœpfi)* new to the fauna of Nova Scotia. By H. Piers 110
Fletcher, Hugh, *B. A.*—Geological nomenclature in Nova Scotia: the Devonian 235
Geological nomenclature in Nova Scotia: New Glasgow conglomerate 323
Flora, Early intervale, of eastern Nova Scotia. By C. B. Robinson 502
Flowering of plants. *See* Phenological observations.
Fossils, possibly Triassic, in glaciated fragments in the boulder-clay of King's County, N. S. By Prof. E. Haycock 376
Fox, J. J., obituary notice of. By A. McKay xxxvi
Freezing-point depression constant for electrolytes, Determination of. By T. C. Hebb 409

PAGE

Freezing-point depressions of dilute solutions of electrolytes, Determination of. By T C. Hebb 422
Freezing-point, Depression of, by mixtures of electrolytes. By J. Barnes. 139
Freezing-point depressions for electrolytes. By Prof. J. G. MacGregor .. 211
Fresh water sponge [*Heteromeyenia macouni*, n. sp.] from Sable Island. By A. H. MacKay, LL. D. 319
Gaspereau Valley, Geological history of. By Prof. E. Haycock.......... 361
Geological investigation in Nova Scotia, Progress of. By R. W. Ells, LL.D. 433
Geological nomenclature in Nova Scotia: the Devonian. By H. Fletcher, B A. 235
Geological nomenclature in Nova Scotia: New Glasgow conglomerate. By H. Fletcher 323
Gilpin, Edwin, jr., *LL. D.*—Further explorations in the Torbrook iron district. (Title only.) lxxix
  Minerals for the Paris exhibition 248
  New mineral discoveries in Nova Scotia 79
Halifax, Worm trails in slates of. By H. S. Poole 453
Harvey, *Rev.* Moses, *LL D*, death of lxxxv
Haycock, *Prof.* Ernest.—Fossils, possibly Triassic, in glaciated fragments in the boulder-clay of King's County, N. S. 376
  Geological History of Gaspereau Valley, Nova Scotia 361
  Kings Co Branch of the N. S Institute of Science: outline of purposes and aims cix
  Records of Post-Triassic changes in King's County, N. S. 287
Hebb, Thomas C., *B. A.*—Determination of freezing-point depression constant for electrolytes 409
  Determination of freezing-point depressions of dilute solutions of electrolytes 422
  Variation of rigidity of vulcanized indiarubber with tension 273
Heteromeyenia macouni, n sp. *See* Fresh water sponge from Sable Island. By A. H. MacKay, LL. D. 319
Hübnerite. *See* Notes on a Cape Breton mineral containing Tungsten. By H. S. Poole, F. R. S. C. 245
Humble-bee's nest, Unusual site for By H S. Poole, F. G. S. xlix
Hydrochloric acid, solutions of. *See* Barnes, J. 129
Ice, drift, as an eroding and transporting agent. By W. H. Prest 333
Ice, drift, as an eroding and transporting agent, supplementary note on. By W. H. Prest 455
Ichthyoidichnites acadiensis, n. sp. By H. M. Ami, D. Sc. 330
Indiarubber, Variation of rigidity of vulcanized, with tension. By T. C. Hebb 273
Indiarubber, vulcanized, Notes on the variation with tension, of the elastic properties of. By Prof J. G. MacGregor and W. A. Macdonald xxviii
Infusorial earths of the world, and the iceberg period. By Dr. A M. Edwards. (Title only.) xix

PAGE

Intervale flora, Early, of eastern Nova Scotia. By C. B. Robinson 502
Ionization coefficients. *See* Archibald, E. H. 33
Ionization, On finding the, of complex solutions of given concentration, and the converse problem. By Prof. J. G. MacGregor, D. Sc. . 67
Ionization. *See also* Barnes, J.
Iron field, Nictaux, Recent developments with calyx drill in. By D. Weatherbe 350
Jaggar, *Miss* A. Louise.—Notes on the Flora of Digby County, N. S. (Title only.) c
Jones, John Matthew, Sketch of life By H. Piers.................. lxxx
Kentville, N. S , Notes on Dr. Ami's paper on Dictyonema slates of. By H. M. Poole 451
Kentville, N S., Upper Cambrian age of Dictyonema slates of. By H. M. Ami, D. Sc.. 447
Kings County, N. S., Records of Post Triassic changes in. By Prof. E. Haycock 287
Kings County, N. S. *See also* Gaspereau valley 361
Kings County Branch of the N. S. Institute of Science: outline of purposes and aims of. By Prof. E Haycock.................... . cix
See also p. xcviii.
Knoydart formation (Eo-Devonian) of Antigonish Co., N. S., description of tracks from. By H M. Ami, D. Sc 330
Labrador plants, collected by W. H. Prest north of Hamilton Inlet, from June to August, 1901. By A H. MacKay, LL. D. 507
Librarian's Report (1897-8), xv. (1898-9), xlii. (1899-1900), lviii. (1900-1), xcviii.
Lindsay, Charles F.—Presence of acid sulphate of copper in mixtures of aqueous solutions of sulphuric acid and copper sulphate 205
Macdonald, W. A., *and* MacGregor, *Prof.* J. G.—Notes on the variation with tension, of the elastic properties of vulcanized india-rubber. xxviii
MacGregor, *Prof.* James Gordon, *D. Sc.*, *F. R. S.*—Diagram of freezing-point depressions for electrolytes 211
Finding the Ionization of complex solutions of given concentration, and the converse problem 67
Laws of dilution for aqueous solutions of electrolytes. (Title only) . xlviii
Use of the Wheatstone bridge with alternating currents. (Title only.) lxii
and Macdonald, W. A.—Note on the variation with tension, of the elastic properties of vulcanized india-rubber xxviii
McKay, Alexander.—Presidential address [(a) Obituary notices of John Somers, M. D., Jules Marcou, and Rev. John Ambrose, D. C. L.; (b) Notes on the early history of the Institute; (c) The position of science in our educational system.]...................... .. i
Presidential Address —[(a) Review of year's work; (b) Obituary notice of J. J. Fox and Sir J. W. Dawson; (c) The utility of a scientific library and a properly equipped museum.] xxxv

PAGE

MacKay, A. H., *LL. D.*, *F. R. S. C.*—Condensed form of *Botrychium ternatum* xcix
Description of section of Stigmaria 346
Diatomaceæ of Nova Scotia xix
Freshwater sponge [*Heteromeyenia macouni*, n. sp] from Sable Island 319
Labrador plants, collected by W. H. Prest on the Labrador coast north of Hamilton Inlet, from June to August, 1901 507
Material taken from the bottom of the Atlantic by the Cable S. S. "Minia" 1
Note on gravel taken by the mushroom-anchor of the "Mackay-Bennett," cable steamer, from the bottom of the Atlantic, 40 miles west of Sable Island. (Title only.) lxi
Phenological observations, Canada, 1898 91
Phenological observations, Canada, 1899 303
(1) Phenological observations of Botanical Club of Canada, 1900; (2) Abstract of phenological observations on flowering of ten plants in Nova Scotia, 1900; with (3) Remarks on their phenochrons... 379
Phenological observations in Nova Scotia and Canada, [1901] 486
Presidential address [(a) On the scope of work of the Institute; (b) Provincial Museum and Science Library; (c) Death of Capt. Trott and Rev. A. C. Waghorne] liii
Presidential address, 1901. [(a) Obituaries of Dr. J R. DeWolfe, Capt. W. H. Smith, and Rev. Moses Harvey; (b) Work of the Institute; (c) Provincial Museum and Science Library; (d) Provincial Progress; (e) Malaria, yellow fever and Sheep-fluke Object Lessons; (f) Marine Biological Station.] lxxxiv
Sub-divisions of the Carboniferous System of Eastern Canada xlvii
McLachlan, R. W.—Talk on Roman Coins. (Title only.) lxxxiii
Magee, W. H., *Ph. D.*—The rare earths; their scientific importance as regards the periodic law lxii
Marcou, Jules, obituary notice of. By A. McKay iv
Material taken from bottom of the Atlantic by Cable S. S. *Minia*. By A. H. MacKay, LL. D 1
Members, Lists of; 1898-99, Appendix I; 1899-1900, Appendix II; 1900-01, Appendix III; 1901-02, Appendix IV.
Mineral discoveries, new, in Nova Scotia. E. Gilpin, jr, LL. D 79
Minerals for Paris exhibition. By E Gilpin, jr., LL. D 248
Mole, star-nosed, (*C. cristata*), its breeding habits, etc By W. L. Bishop 348
Money, Natural history of. By Prof. J. Davidson 179
New Canaan, N. S., Notes on Dr. Ami's paper on Dictyonema slates of. By H M. Poole 451
New Canaan, N. S., Upper Cambrian age of Dictyonema slates of. By H. M. Ami, D. Sc 447
New Glasgow conglomerate. By H. Fletcher 323
New mineral discoveries in Nova Scotia E. Gilpin, jr., L.L. D 79
Nictaux iron field, Recent developments with calyx drill in. By D'A. Weatherbe 350

PAGE

Notes on Dr. Ami's paper on Dictyonema slates of Angus Brook, New Canaan and Kentville, N. S. By H. S. Poole 451
Notes, Supplementary, on drift ice as an eroding and transporting agent. By W. H. Prest 455
Nova Scotia, Progress of geological investigation in. By R. W. Ells, LL. D.. 433
Obituary notices. *See* Ambrose, Rev. J. ; Dawson, Sir J. W ; DeWolfe, Dr. J. R. ; Fox, J. J. ; Harvey, Rev. M. ; Marcou, J. ; Somers, Dr. J. ; Smith, Capt. W. H. ; Trott, Capt. ; Waghorne, Rev. A. C.
Observations on a fish *(Chylomycterus schœpfi)* new to the fauna of Nova Scotia. By H. Piers 110
Officers for 1898-9, xvii. 1899-1900, xlvi. 1900-01, lviii. 1901-02, xcviii
Paris exhibition, Minerals for. By E. Gilpin, jr., LL. D................ 248
Pasea, C. M.—On a relation between the ionization coefficients of electrolytes, and its application as an interpolation formula. (Title only) xlix
Periodic law. *See* Rare earths lxii
Peter, *Rev. Brother* Junian.—Exhibition of a collection of dried plants from the vicinity of Buffalo, U. S. A.................................. lii
Phenological observations, Canada, 1898. By A H. MacKay, LL D.... 91
Phenological observations, Canada, 1899. By A. H. MacKay, LL. D.... 303
(1) Phenological observations of Botanical Club of Canada, 1900 ; (2) Abstract of phenological observations of flowering of ten plants in Nova Scotia, 1900 ; with (3) Remarks on their phenochrons. By A. H. MacKay, LL. D... 379
Phenological observations in Nova Scotia and Canada, [1901].—By A. H. MacKay, LL. D. 486
Piers, Harry.—Notes on Nova Scotian zoology ; no. 5. (Title only.) xxxiv
Observations on a fish *(Chylomycterus schœpfi)* new to the fauna of Nova Scotia 110
Sketch of life of Andrew Downs, founder of first zoological garden in America cii
Sketch of life of J. M. Jones... lxxx
Plants, Flowering of. *See* Phenological observations.
Plants, Labrador, collected by W. H. Prest north of Hamilton Inlet, June to Aug., 1901. By A. H. MacKay, LL. D 507
Poole, Henry S., *F. G. S., F. R. S. C.*—Description of the Davis Calyx Drill. (Title only.)... lix
Notes on a Cape Breton mineral [Hübnerite] containing Tungsten, and on effect of washing certain Cape Breton coals.......................... 245
Notes on Dr. Ami's paper on Dictyonema slates of Angus Brook, New Canaan and Kentville, N. S.. 451
Notes on the periodical appearance of ants in a chimney, and on an unusual site for a humble-bee's nest xlix
Stigmaria structure... 345
Worm trails in slates of Halifax 453

PAGE

Portraits: Somers, Dr. J., op. p. i. Gilpin, Dr. J. B, op. p. xxxv. Jones, J. M., op. p. liii. Downs, Andrew, op. p. lxxxiii.
Post-Triassic changes, Records of, in Kings County, N. S. By Prof. E. Haycock ... 287
Potassium chloride and sulphate. *See* Barnes, J. ... 49
Potassium sulphate. *See* Archibald, E. H. ... 33
Presence of acid sulphate of copper in mixtures of aqueous solutions of sulphuric acid and copper sulphate. C. F. Lindsay ... 205
President's address: (1898, A. McKay), i. (1899, A. Mackay), xxxv. (1900, Dr. A. H. MacKay), liii. (1901, Dr. A. H. MacKay), lxxxiv.
Prest, Walter H.—Drift ice as an eroding and transporting agent ... 333
Labrador plants collected by. By A. H. MacKay, LL. D. ... 507
Supplementary notes on drift ice as an eroding and transporting agent 455
Prichard (A. H. Cooper)—Exhibition of Roman coins of Provincial Museum ... lxxxiii
Progress of geological investigation in Nova Scotia. By R. W. Ells, LL. D. 433
Rainfall notes, Nova Scotia. By F. W. W. Doane ... 399
Rare earths: their scientific importance as regards the periodic law. By W. H. Magee, Ph. D ... lxii
Recent developments with calyx drill in Nictaux iron field. By D'A. Weatherbe ... 350
Records of Post-Triassic changes in Kings County, N. S. By Prof. E. Haycock ... 287
Reid, A. P., *M. D.*—Exhibition and explanation of a model of a sanatorium for consumptives ... xxvii
Report of librarian (1897-8), xv. (1898-9), xlii. (1899-1900), lviii. (1900-1), xcviii.
Report of treasurer, (1897-8), xv. (1898-9), xli. (1899-1900), lviii. (1900-1), xcvii.
Report on Wolfville Branch of the Institute. By Prof. E. Haycock ... xcviii
Rigidity of vulcanized indiarubber, Variation of, with tension By T. C. Hebb ... 273
Riversdale formation. *See* Sub-divisions of Carboniferous system in eastern Canada. By H. M. Ami, D. Sc ... 162
Robinson, C. B.—Early intervale flora of eastern Nova Scotia ... 502
Rubber. *See* India-rubber.
Russell, Lee, *B Sc* School-rooom air ... xxi
Sable Island, Freshwater sponge [*Heteromeyenia macouni*, n. sp.] from. By A. H. MacKay, LL. D ... 319
School-room air. By L. Russell, B. Sc ... xxi
Science, Position of, in our educational system. By A. McKay ... viii
Smith, *Prof.* H. W., *B. Sc.*—Rotation of crops. (Title only.) ... lx
The Preservation and use of the tops of turnips and other root crops. (Title only.) ... lx
Smith, *Capt.* W. H., death of ... lxxxiv
Sodium sulphate. *See* Archibald, E. H ... 33

PAGE

Solutions. *See* Archibald, E. H.; Barnes, J.; Lindsay, C. F.; MacGregor, J. G.

Somers, John, *M. D.*—Obituary notice of. By A. McKay iii

Sponge, Fresh water, [*Heteromeyenia macouni*, n sp.] from Sable Island. By A. H MacKay, LL. D 319

Star-nosed Mole (*Condylura cristata*), its breeding habits, etc. By W. L. Bishop 348

Statistics of expenditure and consumption in Canada. By Prof. J. Davidson 1

Stigmaria structure. By H. S. Poole 345

Sub-divisions of Carboniferous system in eastern Canada, with special reference to position of Union and Riversdale formations of Nova Scotia, referred to Devonian system by some Canadian geologists. By H. M. Ami, D. Sc 162

Sub-divisions of the Carboniferous system of eastern Canada. By A. H. MacKay, LL. D xlvii

Sulphate of copper, acid, in mixtures of aqueous solutions of sulphuric acid and copper sulphate. C. F. Lindsay 205

Sulphuric acid, solutions of. *See* Barnes, J 129

Supplementary notes on drift ice as an eroding and transporting agent. By W. H. Prest 455

Tracks [*Ichthyoidichnites acadiensis*, n. sp.] from fine-grained silicious mudstones of Knoydart formation (Eo-Devonian) of Antigonish Co, N. S. By H. M. Ami, D. Sc 330

Treasurer's report (1897-8), xv. (1898-9), xli. (1899-1900), lviii. (1900-01), xcvii.

Trott, Capt., death of lvii

Tungsten, Notes on a Cape Breton mineral [Hübnerite] containing. By H. S. Poole 245

Union and Riversdale formations of Nova Scotia. *See* Sub-divisions of Carboniferous system in Eastern Canada. By H. M. Ami, D. Sc 162

Upper Cambrian age of Dictyonema slates of Angus Brook, New Canaan and Kentville, N. S. H. M. Ami, D. Sc 447

Variation of rigidity of vulcanized indiarubber, with tension. By T. C. Hebb 273

Ventilation. *See* School-room air.

Viscosity of aqueous solutions. *See* Barnes, J. 113

Vulcanized indiarubber, Variation of rigidity of, with tension. By T. C. Hebb 273

See also India-rubber.

Waghorne *Rev.* A. C., death of lvii

Washing Cape Breton coals, Notes on effect of. By H. S. Poole, F.R.S.C. 245

Weatherbe, D'Arcy, *C. E.*—Recent developments with calyx drill in Nictaux iron field 350

Wolfville branch of the Institute, Report on. By Prof. E. Haycock xcviii

See also p. cix.

Worm trails in slates of Halifax. By H. S. Poole 453